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NOVEMBER 1959

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Published by The Society of Automotive Engineers

1959 Technical Report No. 5

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Designing becomes electra **26**

Design features of the Electra's hydraulic, fuel, and integral engine starting systems, and cockpit have contributed to its performance, safety, and comfort. This article discusses the reasons why. — **R. W. Partridge, V. S. Upton, and J. T. Power**

Russians put more machines on farms **32**

Even though admittedly great progress toward farm mechanization has been made in recent years, it must be objectively appraised that by any measure, Soviet agriculture today falls far short of being highly mechanized or even reasonably modern when compared to what has been accomplished in capitalistic United States. (Paper No. 93T) — **Karl D. Butler**

Snark fuel system heeds ten commandments **35**

Simplified system design was the greatest single factor for attainment of reliability in the SM-62A Snark missile system. Engineers adhered to all points of the "ten commandments" in redesigning the system. (Paper No. 101U) — **B. Bradford Richardson**

Cooperation in research **38**

This article includes the ideas and information which President Raymond has presented during his administrative year to many SAE Sections, and to meetings of automotive engineering societies in England, France, Germany, Holland, Italy, and Sweden. — **Leonard Raymond**

Designing strength into drive lines **49**

Strength is of major importance in any drive line. Provision must be made to accommodate the maximum forces that can be applied. Experimental strength analyses can result in sounder structures — and in accelerated development time. (Paper No. 95U) — **Martin A. Erickson**

Asbestos-reinforced plastic laminates **54**

Erosion and ablation resistance, and strength at high temperatures of asbestos-reinforced plastic laminates were tested in simulated rocket environments. Both phenolic and silicone resins — reinforced by long-fibered chrysotile asbestos — were tested. (Paper No. 106V) — **Norman E. Wahl**

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Additives cut the incidence of stalling by two-thirds during an extensive series of field tests last winter. When the 90 cars tested used a normal production gasoline having a 50% point of 206 F, stalling occurred in 43% of the observation periods . . . under the atmospheric conditions most conducive to icing (40 F ambient and 100% relative humidity.) (Paper No. 86V) — **R. E. Steinke and H. W. Sigworth**

New linkage system for harrows 58

A new linkage system between tractor and mounted or semimounted harrow allows the individual harrow gangs to follow irregular ground contours and reduces the tendency of the blades to break because of the restricted movement characteristic of the rigid hitch. The system retains the features of transportability and depth control. (Paper No. 96W) — **D. F. Kampe**

B-58 undergoes cyclic fatigue test 60

Convairs B-58 is being given an extremely comprehensive certification fatigue analysis, which will take two years to complete. (Paper No. 108U) — **C. D. Little**

Hot airframe problems can be solved 62

Hot-airframe design problems can be solved using currently available materials, properly selected and arranged. Exploiting radiant cooling and the advantageous thermal characteristics of materials in design, this article discusses built-up flat plate structures, cylindrical and conical shells, and thermally nonredundant configurations. (Paper No. 104U) — **M. B. Dunn, M. D. Musgrove, and O. T. Ritchie**

Engine unbalance evils can be minimized 70

Higher rotational speeds affect forces produced by unbalance as the square of the rpm . . . bringing major problems, as engine and road speeds keep going up. (Paper No. 114U) — **M. G. Avery**

Reaction front, pressure measured together 73

Equipment has been developed which simultaneously displays (on one oscilloscope screen) the pressure-time and reaction front-time histories in a spark-ignition engine. (Paper No. 83V) — **E. S. Starkman, F. M. Strange, and T. J. Dahm**

Selecting materials for missile bearings 77

Materials for self-aligning, antifriction bearings capable of operating in temperature environments ranging to 800 F and to 1500 F, and accommodating radial loads up to 130,000 lb, were selected through test to meet the requirements of the Navaho missile system. (Paper No. 112U) — **Robert T. Westmoreland and Patrick J. Hanifin**

600 F airborne electrical system is coming 78

The Air Force has initiated a program to develop by 1962 a 600 F airborne electrical generation and distribution system. Based on the material, subcomponent, and component work done to date, there is little doubt that such a system is feasible. (Paper No. 102V) — **John J. Pierro**

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FUELS & LUBRICANTS

GL-4 Oil Problem as Viewed by Petroleum Supplier, F. A. SUESS. Paper No. S158. Condensed listing of manufacturers' service recommendations as refill or makeup axle oil or lubricant and their drain recommendations indicates problems confronting petroleum supplier trying to service adequately cars and trucks; trans-axle and its lubrication problems; concept of developing cooperatively multipurpose gear lubricant that can be used by both car and truck manufacturers.

Used Oil Analysis — What Does it Tell? T. H. HADDEN, W. R. TUURI. Paper No. S164. Laboratory analysis, regardless of methods employed, identifies and measures quantity of contamination present and deterioration of oil itself; liquid and solid contaminants; how they affect engine and lubricating oil, particularly in fleet operation; methods of determining type and amount of contamination; limitations of laboratory analysis.

Radiotracers Reveal Engine Wear During Detergent Oil Filtration Study, H. HALLIWELL. Paper No. 72T. Program investigating effect of use of filters and level of oil detergency of marine diesel lubricating oils; study effects of oil detergency level and filtration on piston ring wear during clean sump operating conditions, and effects of these factors plus addition of contaminants and subsequent filtration on piston ring wear in GM 3-71 diesel engine; tabulated results obtained by means of radio tracer technique.

Surface Ignition — New Look With New Instrument, K. HYATT, V. J. TOMSIC, C. A. MELLINGER. Paper No. 78U. Electronic instrument developed by Du Pont Petroleum Laboratory to obtain data required to assess prevalence of surface ignition in late model cars; technique employed for measuring change in peak pressure occurrence time due to ignition is divided into accumulation of data on magnetic tape, and reduction of these data; results obtained on 97 privately owned 1957 and 1958 model cars.

Surface Ignition as Influenced by Engine Configuration and Fuels — Consumer Type Study in Vehicles, S. HOPKINS, R. J. PECORA, N. ALPERT. Paper No. 78V. Instrumented and consumer type (subjective) evaluations of surface ignition and ignition induced noise in vehicles; comparison of four engine configurations (case wedge, cylindrical wedge, hemispherical, and inverted "V") in standard 1958 and high compression ratio (12/1) versions of engines using representative present and future fuels and additives.

Combustion Noise and Vibration, R. C. TUPA. Paper No. 78W. Laboratory studies of surface ignition effects show that various types of surface ignition, even nonknocking, caused obvious roughness; additives effective in controlling ignition were helpful in reducing vibration and noise; severe and increasingly common occurrence with test engines is shorting of spark plug gaps by grossly migrating light duty deposits under moderate to heavy stress.

Engine Rumble — Barrier to Higher Compression Ratios? R. F. STEBAR, W. M. WIESE, R. L. EVERETT. Paper No. 83U. Studies made at General Motors Research Laboratories to examine phenomena in terms of noise and vibrations that emanate from engine and of pressure development inside cylinder; rumble is result of abnormally rapid pressure build-up in combustion chamber due to multiple ignition of fuel-air mixture by glowing deposits; results of studies made to determine contributions of oils, fuels, and engine operating variables to occurrence and control of rumble.

Flame Speeds and Pressure Rise

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Rates in Spark Ignition Engines, E. S. STARKMAN, F. M. STRANGE, T. J. DAHM. Paper No. 83V. Source of noises associated with combustion process is suspected to be due to various vibrational modes of engine structure and power train; to examine rate controlling factors, instrumentation is developed to display and record simultaneously, on one oscilloscope screen, pressure time and reaction front time histories in engine; ionization gap technique for detecting location of reaction zone, results obtained and implications.

Design and Operation of Petroleum Refinery to Meet Today's Exacting Production Requirements, C. W. COOTE, R. W. ROGERS. Paper No. 86T. Factors influencing design, problems of operation and product control, amount of laboratory work involved in control of plant and blending of products to meet requirements; emphasis is placed on motor gasoline, its production, processing equipment and methods used for determining road octanes.

Field Testing of Automotive Lubricants, L. W. SPROULE, T. F. LONSTRUP, W. C. PATTENDEN. Paper No. 86U. Methods and equipment used in evaluation of crankcase oils and greases; method employed in rating engine for cleanliness and how results are expressed; caravan type tests; comparison of laboratory FL-2 test and caravan fleet results emphasizes importance of correlating laboratory procedures with field results before evaluating oil quality; chassis lubricants, chassis tests, and results of wear measurements for shackles and king pins.

Deicers Prove Effective in Field Tests, R. E. STEINKE, H. W. SIGWORTH. Paper No. 86V. Carburetor icing research made by California Research Corp. in cooperation with Standard Oil Co. of California and British Columbia; data analysis, and preliminary laboratory work; comparison of base fuel, two different surfactants, and freezing point suppressant shows that stalling is greatly dependent on relative humidity and ambient temperature; gasoline anti-icing additives effectively reduce stalling to low level.

GROUND VEHICLES

Governing Systems for Engine and Vehicle Control, M. F. STERNER. Paper No. 80V. Basic design and operation of Holley governor which consists of two basic components, speed sense unit and control or slave unit; it utilizes vacuum as motive force.

Velocity and Mechanical Governors for Over-The-Road Vehicles, G. D. HEDDEN. Paper No. 80W. Principles of operation, construction details, advantages and costs of velocity and mechanical governors for operation on heavy duty equipment such as trucks, buses, cranes, shovels, and other construction equipment.

Approach to Vehicular Governing, L. V. BRADNICK, L. E. BOREN. Paper No. 80Y. Types of governing for intracity bus applications, produced by Pierce Governor Co.; mechanical engine governor limiting maximum speed of engine without interfering with power output; road speed governor, controlling vehicular speed by controlling propeller shaft speed regardless of gearing and engine speed; transmission switch governor for shifting certain types of automatic transmissions from torque converter into direct drive.

Trends in Truck and Bus Electrical Equipment, W. C. EDMUNDSON. Paper No. 81T. Improvements effected in d-c and a-c generators, batteries, cranking motors and ignition systems; discussion extends only to engine electrical components without reference to other electrical accessories except for their load requirements.

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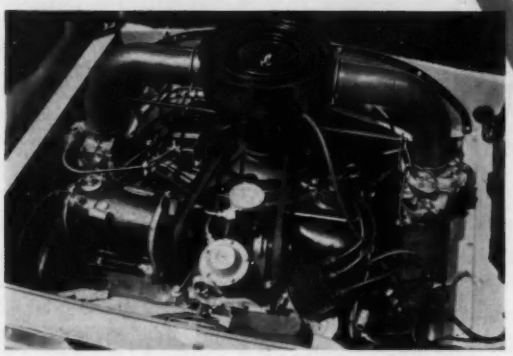

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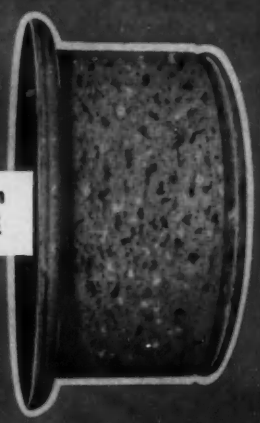

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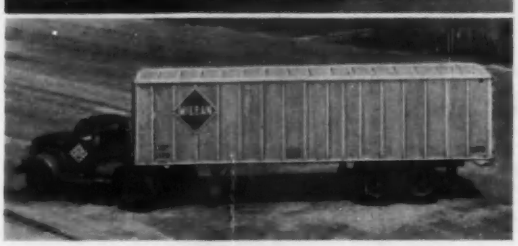

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Look – TERRA-TIRES roam through 12-inch mud!

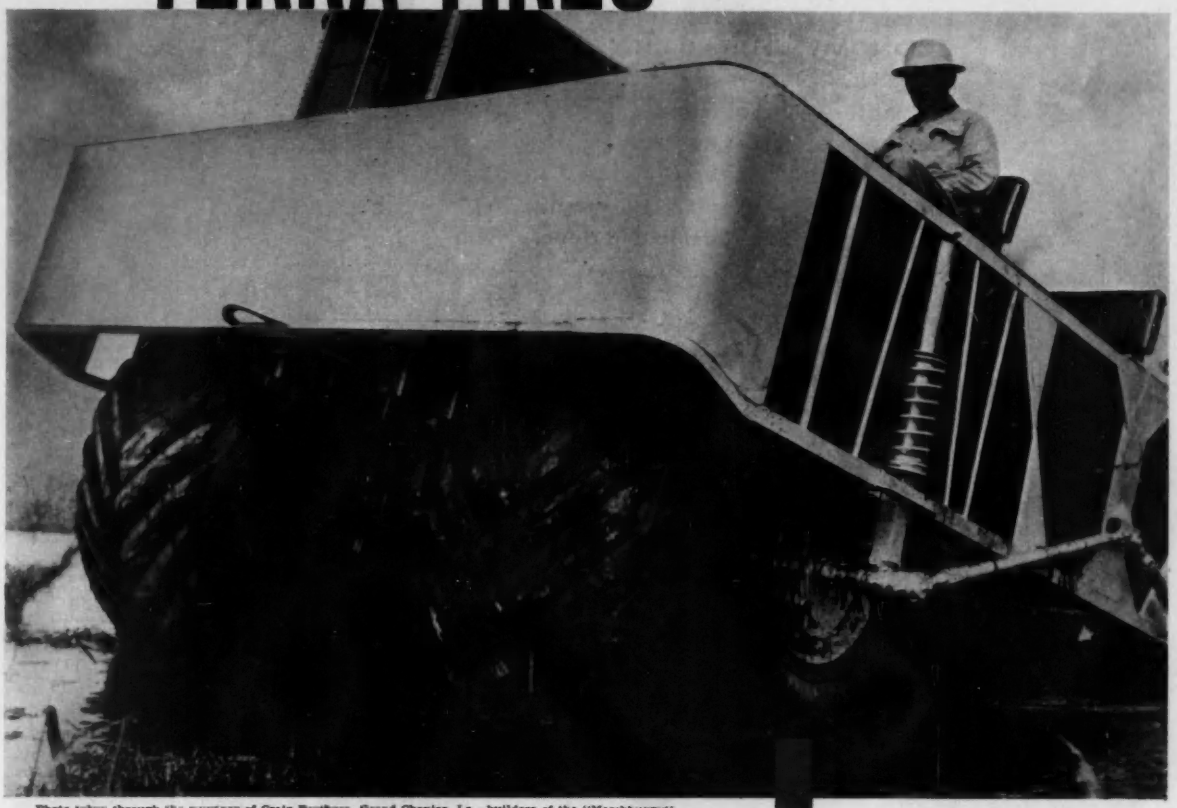

Photo taken through the courtesy of Crain Brothers, Grand Chenier, La.—builders of the "Marshbuggy"

This strange vehicle is called a "Marshbuggy" – and it rolls through some of the mushiest, muddiest marshland in the world on Goodyear's famous Terra-Tires. Try wading through this Louisiana swamp and you'd sink knee-deep in oozing mud. And the stuff is so sticky that it clings like wet paste. Yet Terra-Tires are at home in these treacherous bogs – often carry cargoes weighing up to 4000 pounds *in addition to* the weight of the buggy. This amazing flotation gives Terra-Tires the ability to "go anywhere" – up rough, rocky grades – over soft, shifting sand – even through powder-fine snow. What's the secret of this remarkable mobility? Low inflation pressure – low rolling resistance – great flexibility and surprising strength. Can Terra-Tires solve a mobility problem for you?

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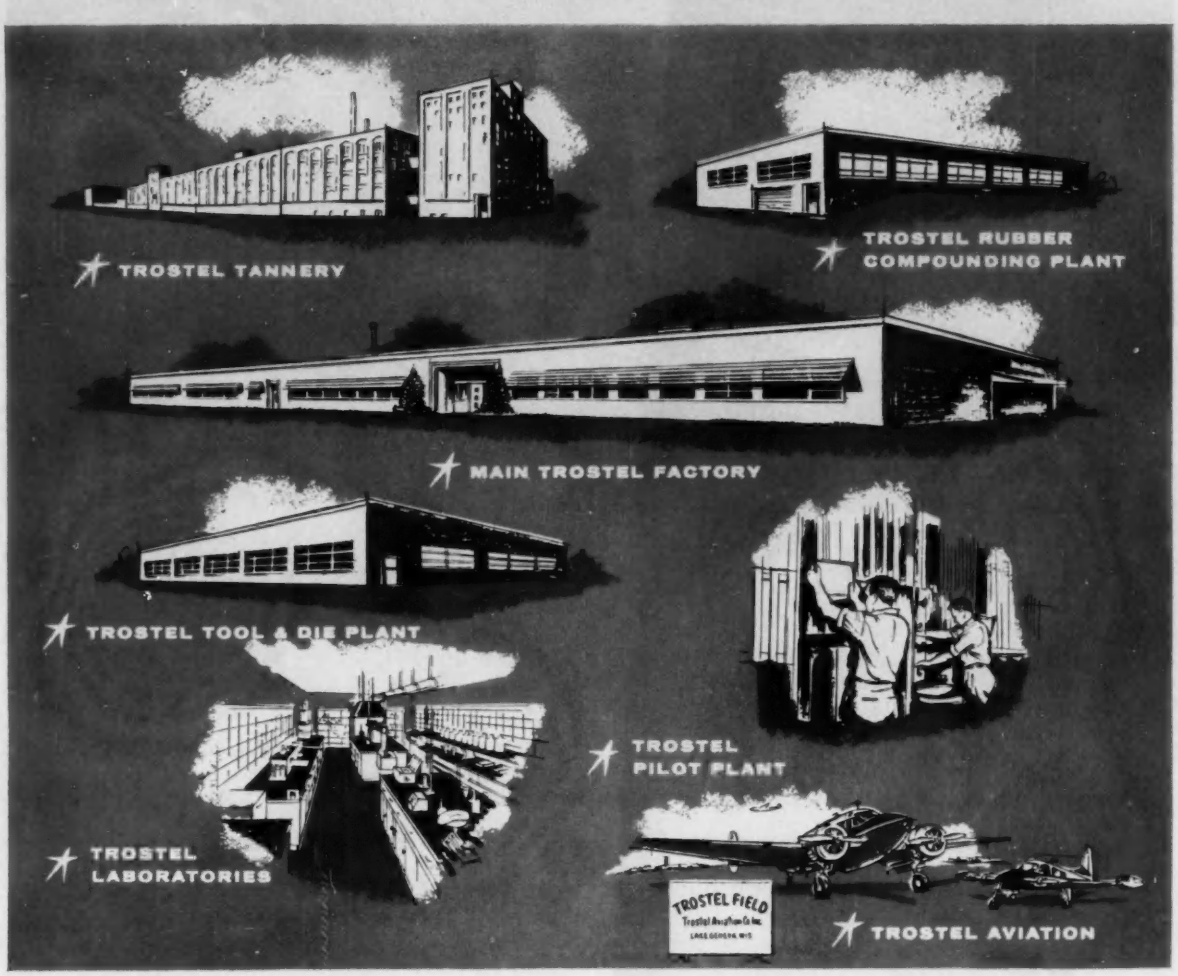

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One of the unique ways in which noise and vibration are isolated by Oldsmobile engineers is through Vibra-Tuned body mountings. These mountings—direct attaching points between the body and frame—are critical to comfort and to the life of the car. If they are not properly placed, severe road vibrations can literally shake the car apart in a few thousand miles. But, by using the most advanced electronic measuring techniques, a softer and quieter ride is achieved by placing the body mounts at the nodal points of the frame. In this way, inherent road vibrations and shocks are practically isolated from the passenger compartment.

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These methods, and many more up-to-the-minute techniques, have enabled Oldsmobile engineers to build consistently fine quality automobiles year after year. Visit your local authorized Quality Dealer and drive a 1960 Oldsmobile. See why it's the most satisfying car you've ever known . . . *the finest the medium-price class has to offer!*

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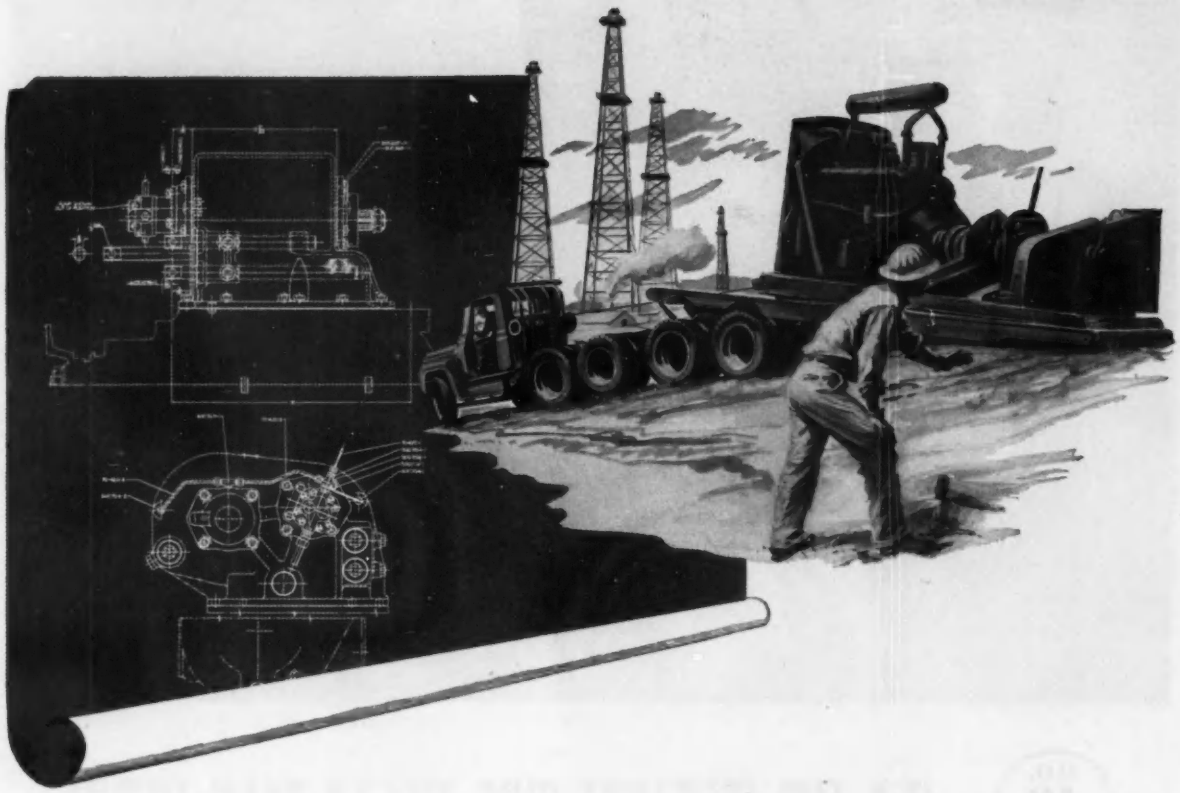
NEW SPICER PTO HAS GREATER CAPACITY FOR HEAVY DUTY WORK



● Rugged, round-the-clock service, where full engine torque is a "must", calls for a top-mounted PTO with the capacity to transmit that torque constantly and smoothly. Whether the vehicle is an oil field rig, a cement mixer truck, or a sand and gravel dump, the job can be done at highest operating efficiency with a Spicer forced-feed, top-mounted power take-off.

The Spicer top-mounted PTO—with either a Spicer 8031 or 8341 auxiliary transmission—outlasts conventional PTO's because positive lubrication is assured at all times, regardless of the operating angle of the vehicle. An oil pump provides forced-feed lubrication at slow speeds with full engine torque.

Spicer top-mounted power take-offs transmit the full torque of the engine with forward transmission in direct drive, or loads equivalent to engine torque with forward transmission in gear, to operate air compressors, heavy duty winches, large pumps and other equipment. Two speeds forward, one speed reverse.

Where definite torque rating of the Spicer PTO is desired, Dana engineers will gladly submit this information upon receipt of complete data on the installation and type of operation.

For further information write Dana Corporation, Toledo 1, Ohio.

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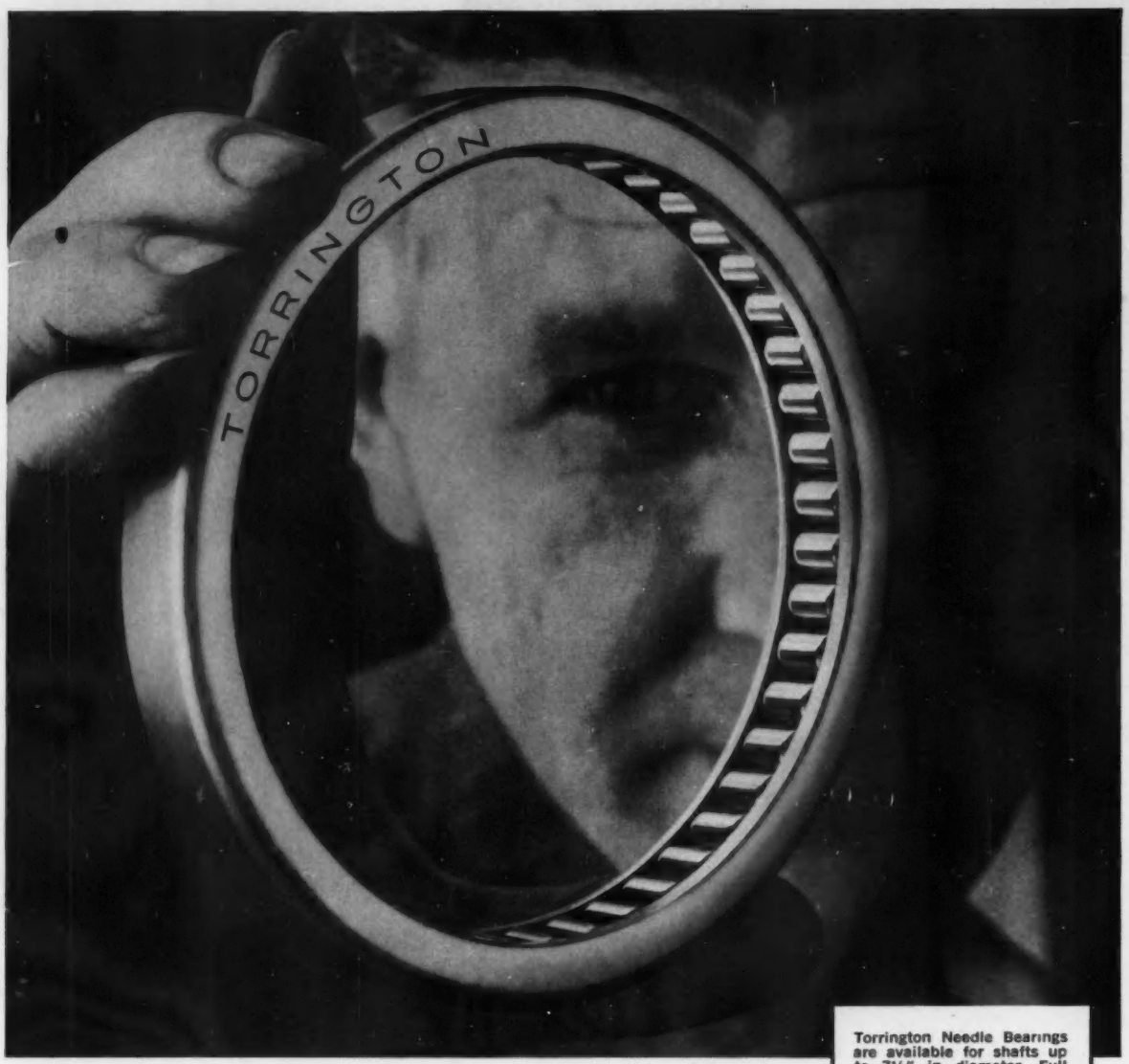

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These advantages have been proved in performance in tractor bolsters, transmissions and final drives. In haybaler crank shafts. In power shovels. In heavy duty hydraulic pumps and starting motors. In road wheel arms on tanks. Why not talk over *your* application with your Torrington representative? **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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SAE journal

For Sake of Argument

Dreaming Dreams . . .

"TOO MUCH BUSINESS LEADERSHIP concerns itself with passing out conclusions; not enough with stimulating people to dream their own dreams."

So spoke a near-to-top executive in the afterglow of a recent SAE committee meeting. Agreeing thoughts came quickly from the small group which hadn't left to catch a plane . . . thoughts like:

The ill effects can be varied — on the company and on the individual. Each of us pushes with most enthusiasm on a program he has helped to develop . . . a program which has been a part of some dream of his own. However sound a spoon-fed idea, it's hard to stir up individual motive power behind its execution. Operational success is likely to equal the degree to which the idea is "bought" by those who have to use it.

. . . And conclusion-spawning managements are not notoriously good salesmen of ideas to their staffs. Too often they resemble the doctrinaire despotism which, Eric Hoffer said recently "wants to obtain by coercion the type of consent that is usually obtained only by the most effective persuasion." Wise is the executive who can eliminate "ought" from his thinking about staff performance . . . unusually wise, the one who takes extra time and trouble to get a staff to "want" to do something.

The importance of getting people to dream their own dreams is emphasized by a General Electric conclusion that "You don't develop a manager; he has to develop himself." No special course of predetermined education seems yet to have been devised to make a man a successful manager. About all his superiors can do is to provide an environment favorable to his self-development . . . make it easy for him to dream his own dreams.

Norman G. Shidle

REASONS WHY VACUUM POWER BRAKING IS FIRST CHOICE ON TRUCKS

WITH BENDIX HYDROVAC* LEADING ALL OTHER MAKES COMBINED

When it comes to power braking, the overwhelming choice on trucks is vacuum power, with Hydrovac leading all other makes combined.

You can bet your bottom dollar that such overwhelming preference is based on solid reasons. For example:

By saving dead weight, vacuum power can add several hundred pounds to *payload*, and earn extra dollars, as ton-miles build up.

In addition, there is the vital *safety stand-by* of instantly available physical braking, instead of "no power, no brakes!"

Then, with vacuum power there is less first cost and less expense for maintenance, and it is completely free of compressor drain on engine power.

Any way you look at it, it will pay you to make Hydrovac Vacuum Power Brakes your choice for the best in power braking . . . for the most in value.

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Bendix AVIATION CORPORATION

chips

from SAE meetings, members, and committees

COMMERCIAL JETS require about 50% longer for servicing than the largest piston-engined transports.

DESIGN REQUIREMENTS for military vehicles and commercial type vehicles are becoming more and more divergent. This is brought about by the fact that civilian-type vehicles are being made to operate in an ideal environment of smooth, hard-surfaced, and gradually sloped roads. Military vehicles, on the other hand, must be designed to give off-road mobility and pose special design problems in regard to such items as the suspension system, tires, wheels, frame, transmission, brakes, and engine.

SHARP BREAK IN DEVELOPMENT RATE of temperature capabilities of aircraft electrical equipment is necessary. If development continues at the rate it has for the past 15 yr, an ambient operating temperature of 550 F would not be reached until 1970. It is certain that operating temperatures considerably higher than this will be reached long before then. That's the reason for the Air Force program described in "600 F Airborne Electrical System Is On the Way." pg. 78 of this issue.

JET STARTING BLAST, on one occasion, picked up a 530 lb baggage cart and blew it over and beyond a blast fence for a distance of some 75 ft. In another case, full power was applied to free tires which had stuck to the pavement in freezing weather. The resultant blast damaged one passenger loading stand, two panel trucks, one air conditioner, one tug, and several glass panels in the terminal building. In still another case, a jet making a stationary full power runup blasted out a 30 × 50 ft area of asphalt pavement.

Most jobs take on the stature of the man who fills them.

AVERAGE OIL DRAIN PERIOD has increased from 1900 miles in 1952 to 3100 in 1958. This 60% increase in drain period has also been reflected in statistics showing that the fall-winter motor oil ratio has drifted steadily downward from 1.60 in 1948 to 0.96 in 1958. The fall-winter motor oil ratio represents the gallons of motor oil sold at filling stations per hundred gallons of gasoline.

OF THE 13,300 INDUSTRIAL DEATHS in 1958, 3300 of them occurred in the farming industry. Only the mining and construction industries exceed farming in deaths per 10,000 workers. Manufacturing has a rate only 21% as high as farming.

NEW YORK INTERNATIONAL AIRPORT recently found it necessary to install a 10½ ft high blast fence 75 ft from the end of a runway to protect vehicular traffic on an adjacent public highway from the blast and smoke from jet takeoffs.

Loyalties are often the product of enthusiasm rather than understanding.

MAGNITUDE of the Thor missile system is impressive in scope and complexity. Consider the following statistics:

- More than 17,000 vendors contribute electrical and mechanical parts to this weapon program.
- More than 150 ground support equipment end items are utilized in the launching of one missile.
- More than 10 miles of piping and tubing support one squadron. (There are four squadrons in each strategic missile wing. Each squadron consists of five positions. A position is made up of three launch emplacements.)
- More than 2500 miles of electrical wire are used in this support system for one squadron.
- More than 1500 meters of all types are used per squadron.
- More than 3000 panel light assemblies are used per squadron.
- More than 50,000 resistors and potentiometers are used per squadron.
- More than 50,000 capacitors are used per squadron.
- More than 5000 relays are used per squadron.
- The power generation system has a peak output of 1050 kw; sufficient for a community of 25,000 homes.

AS SPACE VEHICLES INCREASE IN COMPLEXITY, the internal heat rejection will increase drastically. One megawatt is not excessive as an energy requirement for these types of vehicles. Radiators will thus become intolerably large unless high radiator temperatures are used. For example, approximately 6300 sq ft will be required to dissipate a megawatt at 300 F, while only 400 sq ft are required at 1000 F radiator temperatures.

Designing becomes *Electra*

by

R. W. Partridge, V. S. Upton, and J. T. Power

California Division, Lockheed Aircraft Corp.

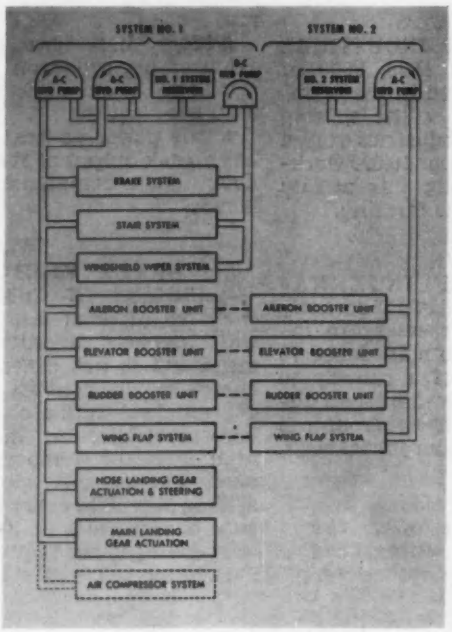


Fig. 1 — Hydraulic system block diagram.

DESIGN FEATURES of the Electra's hydraulic, fuel, and integral engine starting systems, and cockpit have contributed to its performance, safety, and comfort. Here are the reasons why.

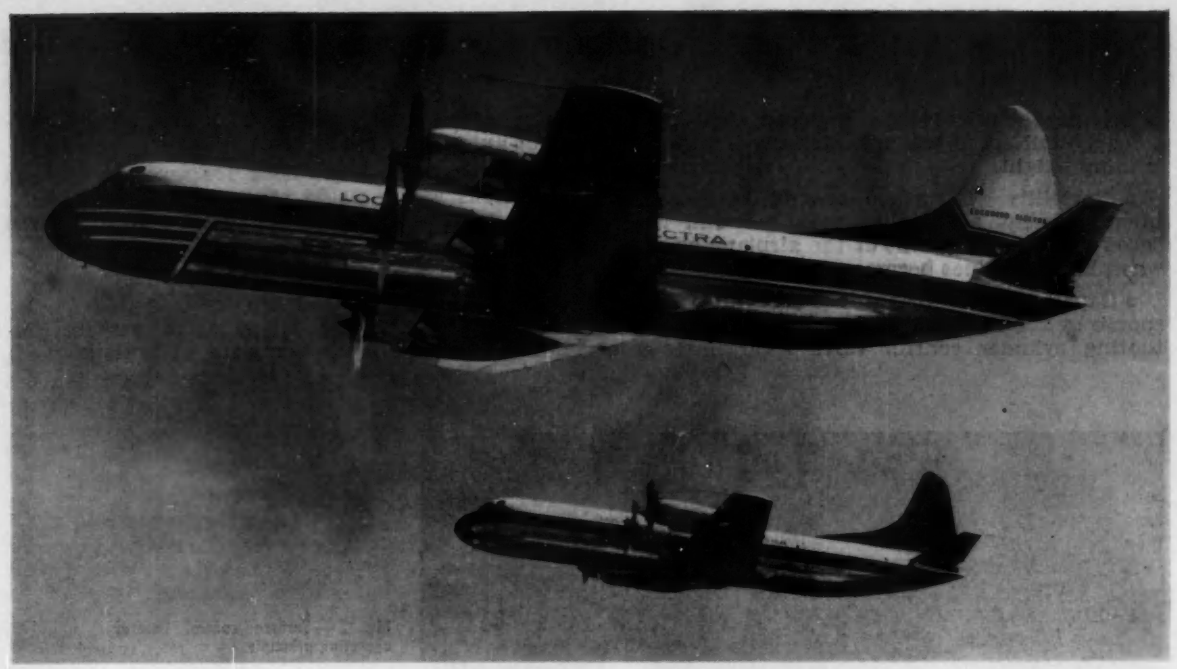
Hydraulic and surface control booster systems

Features of this system include two entirely separate 3000 psi hydraulic systems, electrically driven pumps, and control system boosters which contribute to ease of handling under all conditions.

Separate hydraulic systems — The fluids from one system never mix with the other. Their power output is combined at the surface control by a tandem actuating cylinder with a common piston rod. The significant advantage of this arrangement is that either system could fail without the pilot having to take emergency manual change-over action. . . . The output of either cylinder provides enough surface control hinge moment to fly the airplane under all conditions except abnormal maneuvers. Also, the likelihood of losing fluid from both systems as a result of a component or line failure is extremely remote. Manual control is provided in the unlikely event of complete hydraulic failure.

Fig. 1, a block schematic diagram, shows the loads connected to each system — Nos. 1 and 2. The No. 2 system supplies power for one half of the boosters and wing flap motor loads only, while No. 1 feeds the other half together with landing gear, brakes, etc. The dual motor drive which this arrangement affords the flap system eliminates the need for a separate emergency system, since either motor alone will operate the flaps.

Electrically driven pumps — Because it is electrically driven, the hydraulic system can be operated



Ease of handling in flight and on the ground are designed into the . . .

Lockheed Electra

on the ground by the normally connected electrical ground power source — without engines running or external hydraulic gigs.

A valuable safety factor is that the pumps are removed from the powerplant where they would be near a hot (up to 450 F) compressor casing. This eliminates the need for nonflammable hydraulic fluid. Another safety factor is that any one of the pumps, if suspected of failing, could be merely switched off — while with an engine-mounted pump an otherwise perfectly functioning engine has to be shut down.

Also, an electrically driven pump operates as a constant speed machine, but an engine-driven pump can be called upon for changing flow output at the very time engine rpm is being reduced by an emergency condition.

When changing powerplants, the elimination of hydraulic disconnections means shorter time, elimination of system bleeding, no risk of picking up dirt in the hydraulic fluid, and no risk of hydraulic leaks upon reconnection.

Advantages of control system boosters — Fig. 2 is a schematic showing the booster operating principle. Its advantages include:

- Greater safety with asymmetric power conditions in emergency, and lower minimum speeds for controllability with critical engine or engines inoperative.

- Greater aileron effectiveness resulting in considerable improvement in rolling performance.

- Reductions in surface control areas compared to those required for aerodynamically-balanced systems, due to elimination of air leakage and wastage of area caused by the aerodynamic balance. This in turn reduces the wetted areas and allows for more space chordwise which can be used for fuel tankage. Aerodynamic balanced control surfaces would have increased the Electra weight empty approximately 404 lb. Hydraulic control surface boosters increased the airplane cruise speed for the same power by approximately 10 mph. This results from the fact that the fixed and movable surfaces are smaller with hydraulic boosters. For example, the area of the vertical stabilizer and the rudder is 40% smaller than it would have been with aerodynamic controls. The horizontal tail surfaces are 25% smaller for the same reason. This reduced area accounts for part of the weight reduction.

- Decrease in spanwise size requirements for aileron control surfaces, which increases efficiency by

permitting the use of larger flap span. This permits a lower stall speed which materially improves the landing weight.

- Flexibility of surface control response and hinge moment availability as a material aid to "growth" or development of the airplane as a type when larger engines become available.

- Capability for greatly improved autopilot response by the signals introduced at the booster actuating cylinder control valve itself, instead of through the cable system. This eliminates inefficient autopilot servo systems.

- Elimination of the need for separate built-in gust locks which would otherwise be essential on large transports with aerodynamically-balanced surfaces.

Fuel system

The fuel system uses single point pressure connection, control panel complete with tank gages,

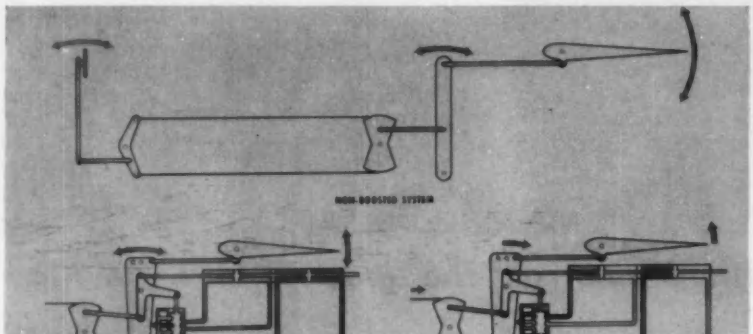


Fig. 2 — Surface control booster operating principle.

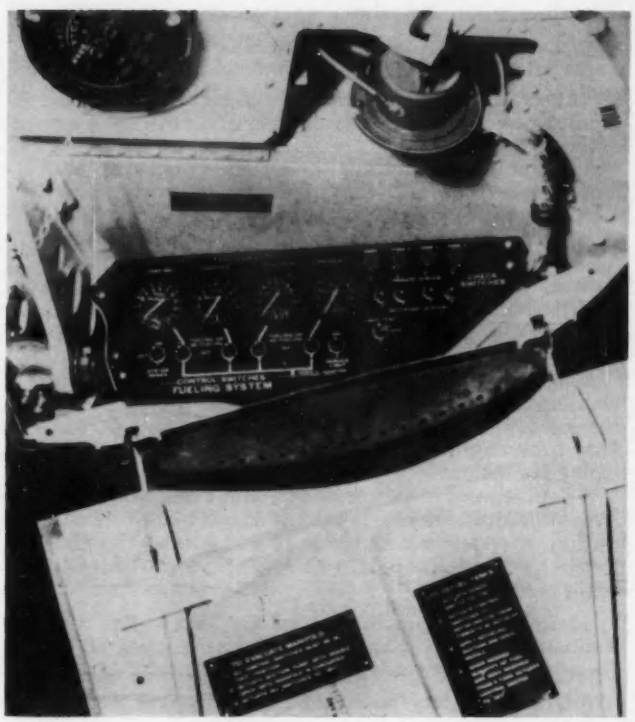


Fig. 3 — Refueling panel.

and a safety pre-check system — all mounted in the No. 3 engine nacelle afterbody. The main reason for incorporating a pressure refueling system was to obtain the ground handling advantages of a single point. Time saving comes from not having to clamber over the wing — an operation which contributes also to wing damage and personnel hazard.

The refueling rate is over 400 gpm and the average elapsed time for filling all four tanks from a typical minimum value to full is approximately 14 min.

The entire arrangement can be divided into: (1) refueling system, (2) engine fuel system, and (3) fuel dump system.

Refueling System — The refueling system permits manual shut-off at any desired quantity by the refueling operator and provides automatic flow shut-off for the full tank condition. The refueling panel is illustrated in Fig. 3 — the four gages correspond to the four tanks. The panel is divided into roughly three functions: (1) system pre-check, (2) refueling, and (3) defueling.

The fuel, fed from a single manifold running along the rear beam, is controlled at each tank by a fueling valve which consists of two poppet valves within a single body. Each half of this dual valve is automatically controlled at the full tank condition by the float shut-off pilot valves, which are also a dual assembly. This double system is designated Primary and Secondary, and either is independently capable of shutting off the fuel automatically. In addition, the fuel vent system is "sized" to accept limited shut-off malfunction without overpressurizing the tank structure. For safety reasons the operating "muscle" for the fueling valves is actually the hydraulic pressure in the fuel truck hose, thus eliminating reliance upon electrical signals for automatic shut-off purposes.

Operation from the panel is extremely simple and consists of: (1) connecting the ground truck fuel source; (2) checking out the Primary and Secondary systems by throwing the switches and observing the indicator lights; and (3) by operating the refueling switches and shutting them off at the desired quantity as indicated either by the refueling panel gages or the refueling truck gage. Defueling is accomplished from the same panel merely be reversing the fueling truck pumps and sucking the fuel out. The refueling manifold can also be drained in the same way after each manual refueling operation if desired from the safety standpoint.

The specification design refueling rate is 300 gpm at 35 psi, the pressure being held to a low value for safety reasons. The system has proved itself capable in practice of rates of 420 gpm when filling all four tanks simultaneously. If the fueling pressure was to be raised to the military standard of 50 psi a rate of 500 gpm is obtainable. Over-wing refueling is provided for use in cases where pressure equipment is not available and one 200 gpm filler well is provided for each tank. Under-wing drip-sticks are provided for very accurate manual fuel measurements — for example, critical route sectors or accurate landing weight requirements.

Engine Fuel System — The engine fuel system (Fig. 4) is very simple and follows closely the ideal arrangement which would be four tanks of identical capacity. The total capacity of 5,520 gal is distributed with 1,100 gal in each inboard tank and 1,660 gal in each outboard tank — so only minimum crossfeeding is normally required except for ranges above approximately 1,800 to 2,000 miles. The natural affinity of turbine fuel for water entrainment constitutes a fuel system strainer or screen icing hazard. Two system components are provided to take care of this: (1) an oil-to-fuel heat exchanger on each powerplant and (2) a bypass check valve at each fuel tank booster pump to prevent feed blockage by icing.

Dump-System — A mechanically operated fuel dump system is provided. The refueling manifold does double duty as the dump manifold. The advantage of this is that the integrity of the dump system is checked automatically every time refueling is performed and the O-rings are always kept wet and free of leaks. Dumping can be carried out from right or left wing independently, but in each case from tank pairs only, i.e., Nos. 1 and 2, or 3 and 4.

Integral engine starting system

To meet the requirements for self-containment, a complete starting system (Fig. 5) is available using

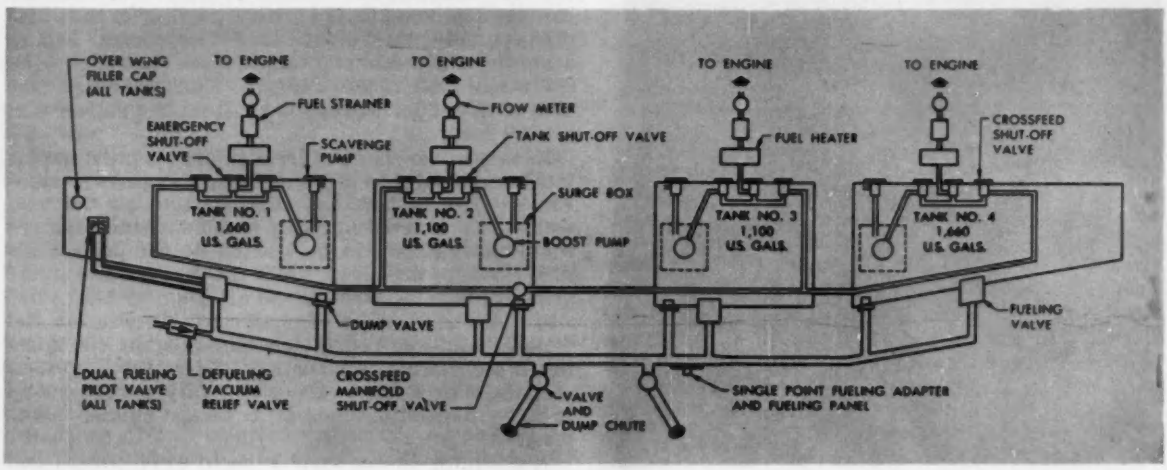


Fig. 4 — Fuel system.

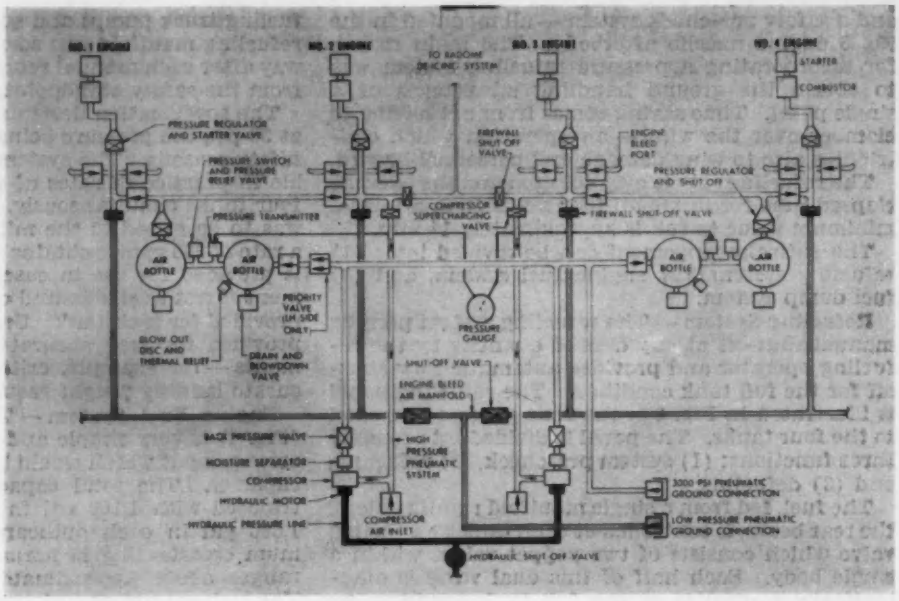


Fig. 5 — Integral engine starting system.

Designing becomes *Electra* . . . continued

air stored in four high pressure bottles together with a "line combustor" in each nacelle. The decision to install this optional system would be based upon an operator's specific requirements of route flexibility, frequency of landing and take-off, and required station transit times. It would have to be evaluated against the weight increase of approximately 600 lb.

In its most complete form, the system uses two pairs of 15½-in. diameter spherical bottles, one pair being mounted in each outboard nacelle. Nominal bottle storage pressure is 3,000 psi and the output pressure is reduced in two stages to a regulated value of approximately 60 psi to feed the line combustors.

The line combustor is really a miniature gas turbine engine burner can which, by burning fuel, adds heat energy to the air to bring it up to 1,000 F. This provides enough total energy to operate the pneumatic starter. Without such a system, the total weight of stored air, if the air was to be used directly, would be prohibitive since starting loads on such a single-spool engine are high and peak at around 160 hp. The line combustor uses engine fuel. It has a continuous ignition system which, together with the control components, is entirely d-c fed so that airplane battery power can be used if necessary. Figure 6 shows the combustor installation together with the other system components. The overboard discharge outlet for the spent air from the starter can also be seen.

Fig. 6 — Combustor installation.

No cross-over starting arrangement is provided for left hand bottles to feed right hand engines or vice-versa. The system contains enough air for two starts. . . . One is normally sufficient since the remaining engines can be started by compressor air bled from the first engine and fed through the cross-bleed manifold. One engine at "high ground idle" will start any remaining engines, whereas at the "low ground idle" condition (10,000 rpm) the combined bleed from two engines is necessary. Design starting time is 15 sec which will vary in practice up to 30 sec depending upon altitude and ambient temperature.

Recharging can be done in flight or on the ground by two small hydraulic motor driven compressors,

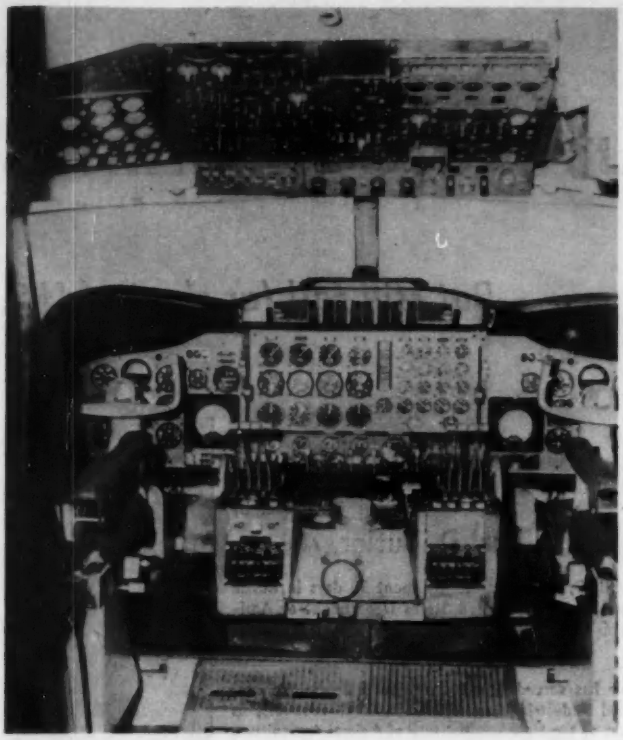


Fig. 7 — Flight station.

one mounted in the aft lower area of each inboard nacelle. The system is arranged so that a priority valve permits the right-hand bottles to be fully charged first thus providing one available start before the left-hand bottles will commence to charge. The system may also be recharged on the ground by a 3,000 psi external air source coupled to the high pressure air connection provided in the right-hand wing leading edge near the wing root.

The in-flight recharging time for one pair of bottles averages approximately 35 min depending upon the air density conditions and the state of bottle discharge. Recharging time under this condition is reduced by the use of a supercharged input to the small compressor, provided from the engine bleed air source. Consequently the recharging time on the ground without engines running is longer — 45 min — because the compressor output is less. Charging of both pairs of bottles takes approximately double the quoted times.

An airplane equipped with this integral starting system can also be started, if required, by an external ground air source instead of internally stored air. Because the starter gear ratio for the line combustor is different from that used in the basic airplane — which is arranged for external starting air sources only — the combustor system is required to function both for external as well as internal starts. Operation is completely automatic with either internal or external starts from the moment that the starter button is pushed until stable engine speed is attained.

Because of the tremendous energy contained in such high pressure bottles, an extensive fail-safe testing program was carried out. This included firing at fully charged bottles with rifles and piercing with explosively driven blades to determine if the pressure would bleed out safely and explosions would be avoided. This program was paralleled by very stringent fatigue life pressure cycling tests up to many times the normal bottle life requirements. Both series of tests were satisfactorily concluded.

Cockpit design

The cockpit conforms basically to the SAE Type II. It is arranged with the flight engineer's seat in the center between the two pilots and with an observor's or check pilot's seat on the left behind the pilot. The arrangement is such that, although designed for a three-man crew, the airplane can be flown by pilot and co-pilot in emergency ferrying operations.

A general view of the flight station is given in Fig. 7. The two main windshield panels are probably the largest on any new transport and provide, in conjunction with the short nose, a downward vision angle of 15 deg. The sliding window panels, one located on each side of the cockpit, are large enough to serve as emergency escape exits for the crew and are certified as such by the Federal Aviation Agency. Separate air temperature control is provided for the flight station when the cabin door is closed, so that the longstanding problem of widely varying comfort levels in crew and cabin areas is eliminated. The radio and electronic rack is partitioned off so that all the hot air is dumped overboard, air for cooling being independently supplied from the main air conditioning system.

Russians put more machines

—But still fall far short of U.S.

Excerpts from paper by

Karl D. Butler, Avco Corp.

DR. KARL D. BUTLER recently spent 30 days in Russia as a member of the United States Department of Agriculture Exchange Delegation studying farm mechanization.

Butler has served on the President's Commission for Increased Industrial Use of Agricultural Products, is Secretary of the National Institute of Animal Agriculture, and is Farm Counselor to Avco Corp.

RUSSIA'S LEADERS are dedicated to technological progress and world economic progress. Even though admittedly great progress toward farm mechanization has been made in recent years, it must be objectively appraised that by any measure, Soviet agriculture today falls far short of being highly mechanized or even reasonably modern when compared to what has been accomplished in capitalistic United States.

How mechanized are farms in the USSR?

Certain farm operations are rather thoroughly mechanized. For example, plowing is largely done with heavy tractors, and tractor-pulled or self-propelled swathers and combines are used in harvesting virtually all of Russia's vast wheat and small grain crops. Power-drawn grain drills sow most of the grain.

By contrast, the hard physical labor, often supplied by women, required to handle wheat, sugar beets, potatoes, silage, and other crops extends almost beyond the imagination of the average American. Nearly all haying is done by hand. Many individual farm operations are highly mechanized; but, compared to the USA, the Soviets are in their infancy in their efforts to bring together the various farm operations into highly-systemized, coordinated, power-mechanized, efficient units.

For example, we are often told that the harvest of sugar beets is almost completely mechanized. True, in recent years a number of mechanical sugar beet harvesters have been placed in use, but the hand labor still required to clean up the beets and get them to sugar mills is appalling.

Table 1 compares selected farm equipment inventory of the USA and the USSR. Table 2 compares selected farm equipment production for 1957.

Electrical power on farms

For 1957, the USSR lists its total agricultural power capacity at 117,100,000 hp, of which 42% was from trucks and over 5% was still provided by draught animals.

Herculean efforts go forward to electrify Russia's farming. Giant electric-power tractors are being used to a limited extent. Eleven or 12% of Soviet cows are milked with electric-powered equipment. About 40% of the collective farms have electricity and it is claimed that 100% of the state farms have electricity. In many cases, electric lights are the principal visible use of electric power.

In 1956, USSR power stations produced 182,000,000 kwh of electricity for agricultural use, compared to 3.8 billion for the USA. Many farms in Russia have their own powerplants. It is estimated that the status of electric power on farms in the USSR is about the same as it was in the USA in 1945. The cost of electric power there is approximately the same as in this country.

Mechanization and manpower requirements

It seems virtually impossible to work out any reasonably accurate comparison of manpower employed

on farms

mechanization.

on farms in the U. S. with that in the USSR. Soviet sources consistently gave us inconsistent figures. For 1956, the official figure for agricultural workers in the Soviet is 33.5 million; but because this does not include young people or elderly people who earn work-day units and for other reasons, qualified students of Soviet manpower believe that their total agricultural working force considerably exceeds this figure.

From what we saw and from figures already mentioned, it is obvious that the Soviets employ an enormous labor force on farms — more than 60% of it women. It is estimated by USDA economists that Soviet agriculture has one worker for about each 15 acres of cropland, while in the U. S. there is an average of about 60 cropland acres per farm worker.

From almost any view one takes of the comparative farm labor situation, one worker in America handles about four times as much cropland as a worker does in the USSR. Much greater farm mechanization in the USA is a dominant factor in this general comparison.

It is very difficult to compare labor productivity of the two countries; but labor efficiency or performance rates for individual crops, as well as live-stock production, give us further clues. The ratio of labor productivity in such cases is usually about 6 to 1, which is a wider ratio than the 4 to 1 based on cropland per worker.

In December, 1958, when Khrushchev reported to the Central Committee of the Communist Party, he said that in the Soviet Union the expenditure of labor on state farms amounted to 80% more per centner (220.5 lb) of various crops, and on collective farms 630% more than in the USA.

Another general comparison is provided in that in Russia there is presently about one tractor to each 400 acres of cropland, whereas in the USA we have one tractor for each 80 to 100 acres.

There is no question but what much of the standard farm equipment in the USSR has been copied from the USA and from Europe. In fact, some of the early tractor and other equipment plants were built by U. S. engineers. The Soviets are now moving ahead on some equipment of their own design, and some of the newer models, equipped with the latest accessories look very interesting. Some of their new equipment exhibited at the recent USSR exposition in New York City showed unique features, and there is little question but what the Russians are developing commendable designs of their own.

That they are moving ahead in mass production

Table 1

Selected farm equipment inventory

	Approximate USSR End of 1958	USDA Estimate USA July 1, 1958
Tractors	1,000,000[a] (about 52% crawlers)	4,500,000 (79% wheel type)
Trucks on Farms	660,000	3,030,000
Grain Combines	500,000[b]	1,050,000
Corn Pickers and Corn Forage Harvesters	170,000	750,000
Field Forage Harvesters		260,000
Sugar Beet Harvesters	30,000	.....[c]
Cotton Pickers	26,000	20,100[e]
Cotton Strippers	.....	23,900[e]
Balers	2,000	600,000
Mowers	299,000[d]	1,615,000 (pto) 805,000 (ground driven)
Rakes	78,000[d]	1,400,000
Plows	718,000[e]	2,990,000
Planting Drills	829,000[e]	1,535,000
Corn and Cotton Planters		2,248,000
Cultivators	616,000[d]	
Manure Spreaders	nil	1,540,000

[a] Official figure, but data from various sources indicate that about 600,000 would be more accurate.

[b] Official figure, but checking indicates 318,000 would be more accurate.

[c] Because of so few producers in USA, actual figures not available.

[d] End of 1955.

[e] End of 1956.

Table 2

Selected Farm Equipment Production — 1957

	USSR	USA
Trucks	126,000	1,083,670
Tractors	145,000 actual number[a] (at capacity)	233,000 (about 50% capacity)
Combines	131,000	44,700
Corn Pickers and Corn Forage Harvesters	51,000 (both)	40,000 (pickers) 18,300 (harvesters)
Sugar Beet Harvesters	8,600	1,600
Mowers	46,000	86,200
Plows	128,000	147,000
Planting Drills	278,000	26,100
Cultivators	208,000	102,500

[a] In terms of 15 hp, they produced 204,000.

methods there can be no question. For example, the Kharkov Tractor Factory produced 50,000 combines in 1958 and plans to produce 65,000 self-propelled units this year. The new units will be powered by 75 hp diesel engines, will be equipped with power steering, and will make good use of hydraulic systems.

To date, much of their equipment is heavy and appears cumbersome. It is not unusual for 2, 3, or 4 operators to ride and busy themselves on a combine or a tractor-swather set-up that would usually require but one operator in this country.

There is evidence that tractors are used more during a year and during their lifetime in the USSR than tractors are here, and that Russian tractors are moderately well serviced and cared for.

Some observers feel that the Soviets possess adequate tractor power in spite of their poor comparison to the USA. Whether more tractor power would further mechanize their agriculture under prevailing conditions is a question, but surely many operations could be further mechanized to advantage and would result in more efficient use of manpower.

Farm transportation

Much of the transportation and hauling around the farms is done with horse and ox power. Also, there is much transportation on roads by wagon. The Soviets are badly underpowered for farm market transportation purposes.

In 1957 in the USSR, there were 631,000 trucks and very few automobiles on farms, compared to more than a million trucks and over 4 million automobiles on U. S. farms the same year.

Apparently there is much less incentive there to use less labor on farms than there is here. The big drive for increased mechanization in the USA is to use capital in the form of machinery to replace manpower that is shifting to other jobs. Apparently there are seasons of the year on farms in the Soviet when much hand labor could be replaced by machinery; but the question of their type of compartmentalized society would be, "What would the seasonally displaced worker do?"

This seems to be another illustration of the disadvantages of a regimented economy where the people are not given freedom to shift to seasonal employment.

Although progress has been made in Russia relative to the mechanization of handling hay, much of it is still done by hand. For example, official statistics of 1957 indicate that 49% of the hay mowing on collective farms was done with machinery. Only 4% was mechanically mowed in 1940 and 17% in 1950. It seems obvious that moving most of the hay from windrows to the barn or to stacks is still done by great hordes of people.

Farm policy contrasted

Farmers in the USA and the Soviet leaders have two different sets of farm policy problems. The USSR has a rapidly-growing population which is becoming increasingly urbanized. In 1926, 82% of Russia's population lived on farms, compared to about 53% today.

With the increased industrial development of the country, there is a growing need for greater farm output. Urbanization is reducing the farm man and woman power and increasing the desire for high-quality diets. In Russia, the government pays a premium for extra milk, meat, and other food production. Dramatically opposed to this, America is trying to learn how to live with food surpluses brought on by wartime expanded production, fantastic application of technological knowledge, and policies established by Congress that guarantee farmers profits to produce crops we do not need.

Farm planning, production goals, price fixing, and the application of scientific technology are rigidly controlled from Moscow; but the responsibility of paying for the new-found technical and supervisory services through various governmental agencies rests largely with the Republics, local collective and state farms, or other decentralized agencies.

Immediate goals

Based on our discussions with Russian officials and scientists, the immediate farm mechanization goals in Russia are about as follows:

1. Increase speed of farm equipment. They are attempting to increase speed by at least 1½–2 times for plowing, cultivating, and all major operations. They now plow about 3–3½ mph and hope to develop equipment to plow 4½–6 mph.
2. Electrify all farms within the next 6–7 yr.
3. Intensify mechanization around farmsteads.
4. To catch up with the USA in the production of meat, milk, eggs, and other animal food products has top priority.

The new seven-year plan, 1959-1965

In Russia's long-range planning, as incorporated in the recently announced 7-yr plan, following are some of the general goals and technical projects in agriculture:

1. Work on farms from electricity to increase 2½ times compared to the past 6 yr.
2. Through increased mechanization, double farm labor productivity on collective farms and increase it on state farms by 60% to 65%.
3. Use 35 million tons of chemical fertilizer compared to 12 million tons in 1958.
4. Continue to greatly expand grain growing as the basis of all agricultural production.
5. Develop machinery to completely mechanize the cultivation of certain crops, such as cotton, sugar beets, potatoes.
6. Expand transport facilities.
7. Further mechanize the animal husbandry industry in order to further expand the output of meat, milk, wool, and eggs.
8. Build more mixed-feed factories.
9. Put out more land reclamation machinery, equipment for materials handling, and manufacture machines for the extraction of peat, lime, and other local fertilizers.
10. Increase the output of spare parts and improve the quality of machinery repairs.

Just how close the USSR will come in meeting these avowed goals is anyone's guess — but that Russia's leaders are dedicated to technological progress and world economic progress there can be no doubt.

To Order Paper No. 93T . . .
. . . on which this article is based, turn to page 6.

Ten Commandments for Design Reliability

1. Provide for absolute mechanical simplicity.

Every element of the system which is not "absolutely reliable" should be challenged in an effort to: eliminate it, simplify it, or otherwise improve its reliability. The components which cannot be eliminated should be studied in every detail for simplicity and maximum reliability. As a rule of thumb, absolute reliability may be taken to be an average of less than one failure in 10,000 parts.

2. There shall be no component in the system which by any stretch of the imagination or ingenuity can be avoided.

A relentless challenge of each component must be made to make sure that it cannot be eliminated by an acceptable change in system configurations or an acceptable change in specified functional requirements or design conditions. Repeatedly challenge each component throughout the program to see if a situation change or an inventive thought can make it possible to remove it. When requirements are added to the system, and it must perform this way and that, then take this golden opportunity for re-examination, rearrangement, elimination, etc. — don't let it just grow. The only sure way to make a functional piece of equipment absolutely reliable is to remove it from the system.

Continued on next page

Snark Fuel System

heeds Ten Commandments . . . becomes more reliable

Excerpts from paper by

B. Bradford Richardson

Norair Division, Northrop Corp.

SIMPLIFIED system design was the greatest single factor for attainment of reliability in the SM-62A Snark missile fuel system. Redesign resulted in the system shown in Fig. 1, and adhered to all points of the "ten commandments":

1. Absolute mechanical simplicity with no electrical functions was achieved in the design of the series phase c.g. control of the fuel system. Orifices replaced functional inertia valves.
2. Eliminated components consisted of flow proportioner, inertia valves, level control valves, precheck solenoids, float switches, gate valves, shut-off valves, pressure regulators, and relief valves.
3. A simple mechanical mechanism in the form of of a venturi, in the fuel-air pressurization line was used to control a shut-off valve regulating fuel transfer. Pump assembly restrictors were used to give the correct tank ratioing for desired c.g. control.
4. A production flight tested fuel booster pump was chosen over a special design.
5. Liberal performance margins were put into the air pressurization system without causing engine thrust losses. The production pump performance margins were ample without weight and power penalties.
6. A reliable type design specification was written

Ten Commandments

— continued from preceding page

3. Simple mechanical mechanisms are more reliable than complex ones.

The ultimate is no moving parts. Challenge every moving part and every separate part to prove that it cannot be eliminated, simplified, or improved. As the saying goes, "If it moves kill it." Avoid delicate hardware. Avoid snap rings. Avoid flow passages small enough to clog with contaminant which could conceivably be present. Close clearance sliding fits are generally to be avoided. Guides of all types, lengths, sizes, and shapes must be carefully designed and tested when used in a component. Materials, lubrication, storage life etc., must be studied in detail.

4. Functional equipment which is already in quantity production is more reliable than equipment developed and built especially for the system.

This is proving out especially in ground support equipment, where costs have been cut considerably. Why use them? Because they have been proved, the bugs have been worked out, and they have been tested, both in the laboratory and in service. Recently the Services, after being requested to make a study to see if they could devise some new method to prove reliability without the increased costs of additional life testing, reported they had found no new method.

An efficient packaging of components, of which there is a trend today, will result in a possible elimination of moving parts and surely less plumbing or wiring, thus eliminating potential points of leakage or power losses.

5. The system shall be designed to have liberal performance margins rather than to be just adequate.

The performance margins shall be judiciously distributed among related functions to avoid a relatively weak link. The system analysis shall show the distribution of margin among related functions. For example: Design vital springs for 20% of normal design stress for the material. Also avoid difficult-to-accomplish physical functions, such as low volume leakage, which is vital.

6. The equipment design specification shall specify the type of air-weapon system the part is to be used for, and that reliability is the major design requirement.

It shall establish detail requirements to protect our reliability philosophy into the design of the component. The liberal performance margins provided by the system design shall not be wasted by allowing loose per-

for each fuel system component. Performance of all pumps fall within a narrow band.

7. A complete fueling and defueling of a finished missile are required. The defueling simulates a flight, in which fuel operates all system components, and is checked against calculated performance figures.

8. Minimum vital-complex functions were maintained with the elimination of one of the two float switches originally needed for ejection of the pylon tanks. The flow proportioner was eliminated. No guidance signals required for c.g. control. Fuel booster pumps run continuously eliminating need for on and off circuitry.

9. Minimum vital human functions were met with no manual control of the onboard fuel system required before launch. A ground support fuel counter with automatic shut-off feature is used for fueling the missile.

10. A high level of reliability has been obtained through no evidence of fuel system equipment component malfunction to date in any of the flights of the missiles carrying this system.

To Order Paper No. 101U . . .
. . . on which this article is based, turn to page 6.

Fig. 1 — Simplified schematic of Snark fuel system. (There is also a launcher fuel system which supplies fuel to the engine prior to launch and thus, the amount of fuel on board and launch c.g. are independent of prelaunch engine run.)

Inflight fuel management has to provide maximum mechanical and operational reliability and also to provide the aerodynamic optimum c.g. gross weight profile. There are two basic ways by which the location of the fuel is controlled to obtain the desired c.g. profile for the missile during flight.

Early in the flight there is the series phase, when it is desired to shift the center of gravity aft as rapidly as possible to reach the optimum cruise c.g. and also to empty the pylon tanks as early as possible so they can be dropped to minimize drag. Later, there is the ratioing phase when it is desired to shift the c.g. aft slowly at a prescribed rate, and maintain the optimum c.g. as gross weight is reduced. This is done by having the forward and aft tanks empty in parallel with a predetermined ratio of flows from electrically driven a-c-powered centrifugal pump assemblies. In the final phase all remaining fuel is in one tank close to the desired center of gravity.

formance requirements in the equipment design specifications.

Under "notes," in the detail component specification, the following should be included: "After successfully passing all qualification tests, approval of a submitted part constitutes authority for the vendor to proceed with the manufacture of additional duplicate parts. If any deviations or substitutions of design, methods, materials or dimensions are made after approval, immediate notification and/or written consent of the engineering department shall be required."

7. The system shall provide for checking every vital function of every component by the System Inspection Test after assembly is complete.

It must be possible to inspect every locking device as installed. Design so that physical interference prevents mis-assembly or mis-installation that is not readily obvious.

8. Provide for absolute minimum vital-complex functions.

By "vital functions" is meant functions which must take place in order for the mission to be completed. By "complex functions" is meant operations of complex mechanisms such as: electrically actuated valves which require signals, external electrical circuits, and electrical reactions such as mechanical mechanisms which involve more than a few maximum reliability physical parts working together.

9. Provide for absolute minimum vital human functions.

By "vital human functions" is meant functions which must be performed by either flight or ground personnel, which require any degree of human judgement or memory, and which must be accomplished properly to complete the mission. "Absolute minimum" in this case not only means the fewest number but, also the simplest, least likely to be done improperly, functions. The need for this objective is based on the relatively high probability that any human function, no matter how simple on paper, will some time or other be done wrong or omitted.

10. Levels of reliability which have been accepted as inevitable for manned aircraft systems and components are generally inadequate for complex missiles.

A new set of relative values must be developed, wherein reliability stands higher with respect to design time, component cost, weight, fabrication convenience, and ground testing cost.

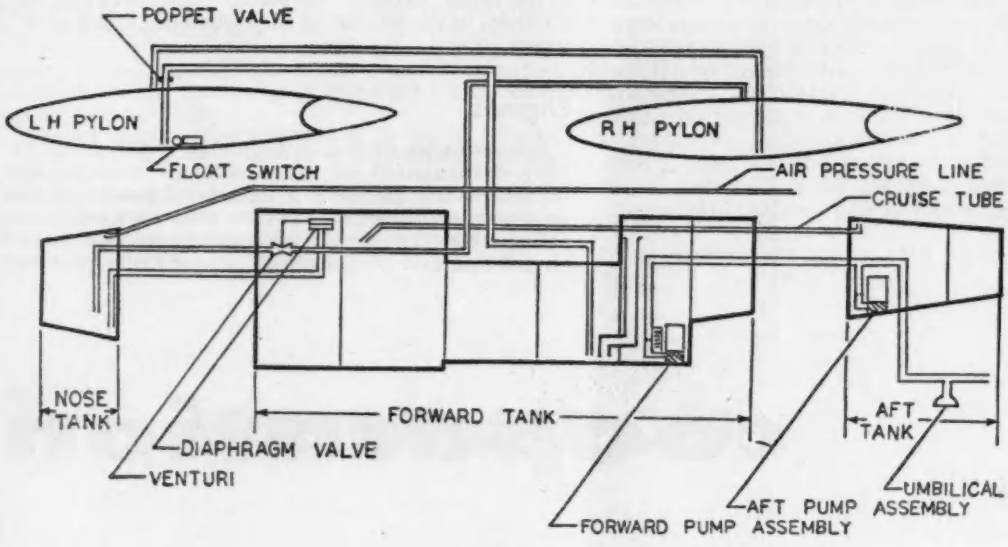


Fig. 1

• This article includes the ideas and information which President Raymond has presented during his administrative year to many SAE Sections, and to meetings of automotive engineering societies in England, France, Germany, Holland, Italy, and Sweden.

cooperation

by
Leonard Raymond
President, Society of Automotive Engineers

THE past three decades have seen an unpredicted and tremendous growth in two vital segments of the American economy, the petroleum industry and the automotive industry.

These two industries have had very closely interrelated and parallel growth in the United States. The close relationship is illustrated by Fig. 1 comparing the millions of cars on the road with the billions of gallons of gasoline consumed annually and with the Gross National Product (total wholesale value of all goods and services). Both have shown a reasonable flexibility and adaptability to change in accordance with the needs and dictates of the market place and in supplying products of constantly improving quality and performance at minimum cost.

Competitive pressures within and outside these industries have been a continuous and growing factor in minimizing the complacency and inflexibility which can be bred all too easily into large companies and industries. However, these competitive pressures have not prevented close interchange and cooperation on matters of mutual interest and concern between the technical men in the two industries, with reciprocal benefits to both.

The Society of Automotive Engineers long has played a major part in this technical and personal interchange, and its publications are eloquent witness to the fact that progress has been possible only through the efforts and contributions from numerous companies and researchers in both industries.

It is probably not far from the mark to state that progress would have been much slower and more costly in both industries without recognition of the mutuality of their problems, leading to active encouragement and support of effective technical cooperation among companies and between industries, to the benefit of their customers and themselves.

Engines

One example of this interchange is the concomitant development of more efficient engines and higher octane gasolines. The development of the post-war American V-8 engine with its greatly increased rigidity opened up an entirely new era of engine and fuel development. Competitive pressure

resulted in a vastly accelerated rate of horsepower increase (Fig. 2), with accompanying competition in other components, such as transmissions, axles, power assist units, suspensions, et cetera.

Some examples of the research problems created by engineering progress in this area follow. These examples have been selected as illustrative without attempting complete coverage.

Increases in compression ratio have been dependent on improvements in fuel anti-knock quality (Fig. 3)[1]. Increases in compression ratio also are dependent on the solution of numerous mechanical, design, combustion, and other problems. As long as knock was the principal form of uncontrolled combustion, the solution to the problem of knock-free combustion from the fuel standpoint was higher octane numbers, particularly higher Research octane numbers to counteract low speed knock.

However, for today's engines of 10 to 1 compression ratio and for tomorrow's engines of even higher ratio — (some have predicted compression ratios approaching those of diesel engines) — other forms of uncontrolled combustion or combustion misbehavior must be overcome (Fig. 4)[2].

Surface ignition is a generic term and supplies in place of one source of ignition, the spark plug, many possible random sources in time and space (Fig. 5)[3]. The result is combustion mal-performance, for which the combustion chamber and engine were not designed, with resultant mechanical, auditory, thermal, and other difficulties (Fig. 6)[4].

On the base fuel side, the solution to knock has been primarily through knowledge of preferred hydrocarbon structures (Fig. 7)[5] and how to achieve them economically in large refineries. For commercial reasons dictated by refinery technology and economics, aromatic type hydrocarbons have become by far the primary route toward higher Research octane number levels. This has been justified as long as the low-speed knock is the most severe requirement. However, there has been a recent tendency by some to regard both part-throttle knock and high-speed knock of sufficient importance to warrant inclusion of Motor Method octane numbers in evaluating fuel anti-knock performance.

Now, surface ignition can be added as a factor of potentially greater importance. In engines of higher than 10:1 compression ratio, surface ignition effects tend fair to become as significant a measure of fuel and engine performance and development as anti-knock characteristics. As both temperatures and speeds have increased, these more severe manifestations of erratic combustion, including preignition, rumble, thud, dieseling, slow knock and after-running, have again entered the picture with a need for some new knowledge for their solution.

These phenomena, with the possible exception of dieseling and slow knock, date back to the early days of the automotive industry. However, they have a new significance today in that their solutions pose much more difficult and formidable problems than was the case thirty to forty years ago. In fact, these problems appear, in the opinion of some experts, formidable enough to cause a change in the historic trend of compression ratio, octane number, and fuel composition. Their solution will require the most talented efforts of the automotive and petroleum researchers, since it now appears that surface ignition problems may limit engine progress and place a ceiling on the most efficient use of such engines unless overcome.

The complexity of the problem of controlling combustion is indicated by the fact that, as in so many phenomena encountered in research work, it is not possible at this time to assign absolute values to the knock, surface ignition, and other combustion characteristics of individual hydrocarbons or mixtures. Attempts have been made to develop envelopes of surfaces of performance in terms of such parameters as mixture temperature-density-time and mixture temperature-spark advance-speed. Such attempts have been of only limited practical utility because of inability to include the effect of other significant parameters, particularly those bearing on the reactions taking place during the conditioning period or the period of chemical and thermal changes occurring prior to the onset of rapid combustion. These changes include cracking, dehydrogenation, polymerization, free-radical formation, and oxidation.

The taming of future wild combustion arising

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[1] Ethyl Corp.

[2] "Rumble — A Deposit Effect at High Compression Ratios" — A. E. Felt, J. A. Warren, and C. A. Hall — SAE Summer Meeting, June 1958.

[3] "Surface Ignition Control by Phosphorus Fuel Additives" — J. B. Hinkamp and J. A. Warren — American Chemical Society, "Industrial & Engineering Chemistry," Vol. 50, 1958, p. 251–256.

[4] "Knock Knock — Spark Knock, Wild Ping or Rumble" — R. H. Perry and H. V. Lowther — SAE Summer Meeting, June 1958.

[5] "Road Octane Numbers of Tomorrow's Gasolines in Tomorrow's Cars" — J. J. Greytak, J. S. Bellah, and W. E. Morris, Proceedings, American Petroleum Institute, 1957, Section III, "Refining," p. 244–255.

in research

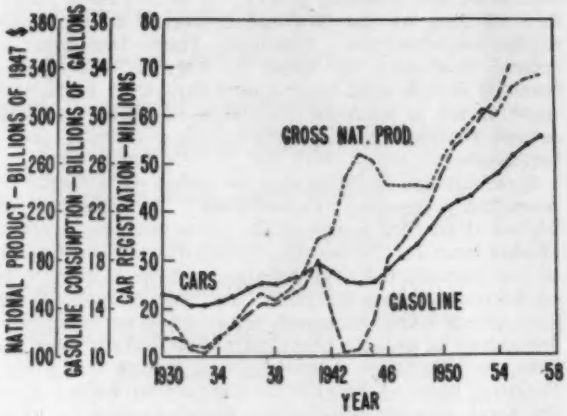

Fig. 1 — Car population, gasoline consumption, and gross national product trend.

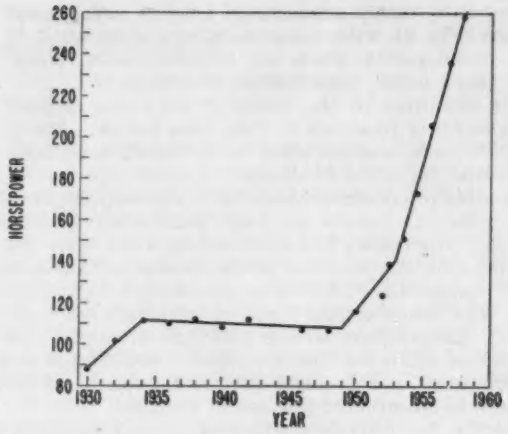

Fig. 2 — Passenger car horsepower trend.

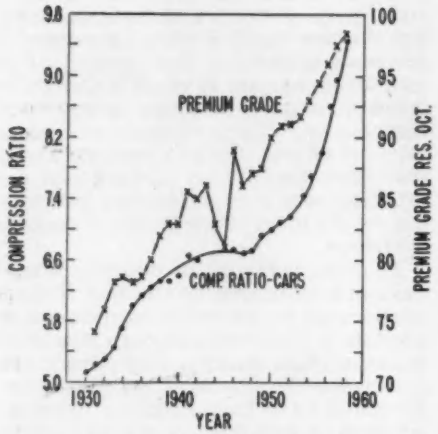

Fig. 3 — Compression ratio and premium grade octane trend. (Ethyl Corp.)

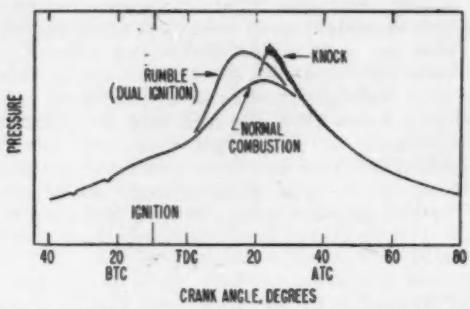

Fig. 4 — Normal combustion, knock and rumble. (Felt, Warren & Hall)

cooperation in research

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from still higher temperatures and pressures may require new knowledge of pre-combustion reactions (cool flames, etc.) and their control; of combustion residues and their elimination as ignition sources; of the combustion characteristics of fuels and fuel components and their susceptibility to thermal, oxidative and additive effects; of lubricants and lubricant additives and their effect on combustion chamber deposits.

The assumption of a major role for surface ignition would carry with it the implication of a different basis for fuel selection than Research octane numbers. At the levels of anti-knock quality required for future engines of higher than 10:1 compression ratio, the choice of hydrocarbons would appear to lie principally in the isoparaffinic and aromatic types (Fig. 8)[6]. Selected isopraffins are excellent in knock and surface ignition resistance and in freedom from surface ignition-producing deposits.

Many of the aromatic hydrocarbons appear to have poor surface ignition resistance and lay down deposits which induce surface ignition. However, it would seem unwise to condemn the aromatics as a group, and a study of individual aromatic hydrocarbons in the proper octane number and boiling range would appear justified as a cooperative project similar to Project No. 45 of the American Petroleum Institute. Cooperative work will be assisted greatly by the development of standard test methods for rating surface ignition performance. These would be similar in usefulness to our present laboratory and road knock test methods and should include evaluation of the differences among individual hydrocarbons in laying down combustion chamber deposits which induce surface ignition. The Coordinating Research Council, through its Combustion Chamber Deposits Group comprised of experts from

both industries, is endeavoring to develop such research techniques. It is hoped that these techniques, when developed, will serve as a common language and as a means of furthering the solution to this difficult problem.

Another element adding to the uncertainty of the problem is the possibility of discovery of a potent anti-surface ignition additive which will be as effective at higher compressions, without harmful side-effects, as phosphorus-containing additives have been to date.

Another petroleum research area from which a contribution to relief of surface ignition may be expected lies in the lubricating oil. The introduction of multi-graded oils free from non-volatile components like bright stock has contributed significantly to reducing Octane Number Requirement Increase (Fig. 9)[7] and surface ignition effects (Fig. 10)[7]. It is probable that further gains can be achieved through lubricating oil and additive research in minimizing detrimental carbonaceous combustion chamber deposits and in modifying the chemical composition and the glow or ignition characteristic.

From the engine designer's standpoint, the problems are at least as formidable, involving control of rate of pressure rise, reduction of combustion chamber deposits, elimination (minimizing) of hot spots, control of clearance volume, ample component and structural strength and rigidity, adequate starting and ignition systems and improved thermal efficiency.

This last item of improved thermal efficiency carries with it some elements of mystery. Available data (Fig. 11)[8] obtained on high compression ratio engines indicate an unexpected levelling-off of the thermal efficiency curve and a significant departure from theoretical gains starting at approximately 12:1 compression ratio. Several theories have been advanced in explanation, including (a) increase in relative quench area causing late and inefficient burning; (b) increased heat dissipation to the cooling water resulting from increased compression and combustion density; and (c) greatly increased piston ring friction resulting from higher combustion pressures. Further work in this area may indicate whether or not a basic and insurmountable physical phenomenon and barrier to higher thermal efficiency is involved.

These formidable technical barriers, briefly described above, explain the belief of some that further compression ratio increases will not follow the long-time trend in the United States. Also, assuming that the many barriers are overcome through the combined efforts of the automotive and petroleum technologists, the cost of the solutions of necessity will have to be weighed against the benefits derived by the car owners.

Engines of higher compression ratio and fuels of higher knock and surface ignition resistance will continue to attract greater research effort and dollars than any other automotive and petroleum prob-

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[6] "The Surface Ignition of Fuels in Engines" — R. H. Blaker, American Chemical Society Meeting, April 10, 1956.

[7] cf. Reference 4.

[8] "A New Look at High Compression Engines" — D. F. Caris and E. E. Nelson, SAE Summer Meeting, June 1958.

A cooperative responsibility

IN THIS ARTICLE, PRESIDENT RAYMOND discusses some of the challenges to the research men in the American automotive and petroleum industries in the years ahead.

The long-range interests of their millions of mutual customers and of the two industries themselves dictate the need for proper decisions as to the responsibilities and contributions of each industry to the solution of their mutual problems.

The objectives in all cases are vehicles and a transport system which will deliver maximum value in terms of optimum performance and customer satisfaction at minimum overall cost.

The overall economics to the customer in terms of performance, satisfaction and cost, he says, should be controlling in arriving at the best balance in contributions of each industry. Every change in performance requirement, or every added performance property necessitates a new set of compromises in the final product. It is easy to arrive at the wrong or the less than optimum compromise or balance with only limited data and the incomplete view which can result.

It is necessary at all times, he brings out, to bring all available information to bear on these problems; to recognize blanks in knowledge and the possible effect of incomplete information on the strength of the conclusions. This is particularly the case where reliability and low relative cost are paramount considerations.

Thus a special obligation is placed on the automotive and petroleum industries jointly to achieve the best combination of products. Much can be done through encouragement of research and adequate freedom of interchange of information.

lem. Because of the tremendous multiplier of approximately 70 million American vehicles (with a total fuel consumption many times all the central electric generating stations in the United States), even a small gain in efficiency means a savings of hundreds of millions of gallons of gasoline per year. Thus, Campbell estimated[9] that a saving of 6% (1 mpg in 15 mpg) is worth about a billion dollars annually, equivalent to the total fuel bill of the American electric utility industry. Since American cars are not designed primarily for fuel economy in the same sense or with the same emphasis as in many cars of European manufacture, a gain of even 1 mpg assumes considerable importance. By the same token, a similar loss in economy should not be and is not regarded lightly by American engineering departments.

Increased compression ratio and improved breathing are the two primary methods of raising specific output. Increased breathing has been achieved by use of multiple-barrel carburetors and multiple carburetors, together with larger valves and ports, changes in cam contour, etc. These are all aimed at higher induction system capacity to inhale more air with less restriction and friction loss. As Ricardo pointed out many years ago, the gasoline engine should be called more properly an air engine; it is relatively easy to deliver excess fuel to the cylinders; the difficult part is in supplying increasing amounts of air.

Very few gains are achieved without price and one example is the valve train (Fig. 12). Larger size valves for better breathing mean increased valve weight, which requires heavier valve springs, particularly if higher speeds are desired. When changed cam contour for more rapid acceleration and faster valve opening is added, the inevitable result is increased unit pressures at the contact between the highly loaded cam and valve lifter. If the dynamic loads, which can exceed 150,000 psi and which approach rear axle gear tooth loads in their magnitude, are miscalculated and prove to be beyond the ability of the metal or lubricant to withstand, the result can be serious and unpredictable difficulties in the form of pitting, spalling, scuffing and accelerated wear of the mating parts (Fig. 13). While increased concentrations of effective extreme pressure agents can be beneficial in conferring a small but needed margin of protection to a borderline cam and lifter wear condition, it is highly likely that design and metallurgical changes can be much more potent corrective measures. Where a borderline condition exists, it may be unsafe to rely on oil formulation change alone as the remedy.

Virtually all of the post-war American overhead valve engines have demonstrated to a greater or less extent that the valve train is the most critical element in the engine in its susceptibility to trouble. With the lower output post-war engines, a variety of metal combinations were used for the camshaft and valve tappets with reasonable freedom from commercial trouble. These included the combinations shown in Table 1[10].

The subsequent increases in valve train loadings

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[9] "Looking Ahead in Fuels for Automotive Transportation" — J. M. Campbell, SAE National Fuels & Lubricants Meeting, November 1957.

[10] "Valves & Valve Gear Design" — Vincent Ayres, API Lubrication Committee Meeting, Detroit, February 16, 1954.

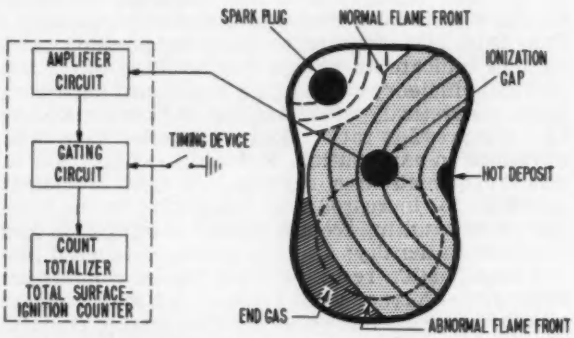

Fig. 5 — Surface ignition and means of detection and counting. (Hinkamp & Warren)

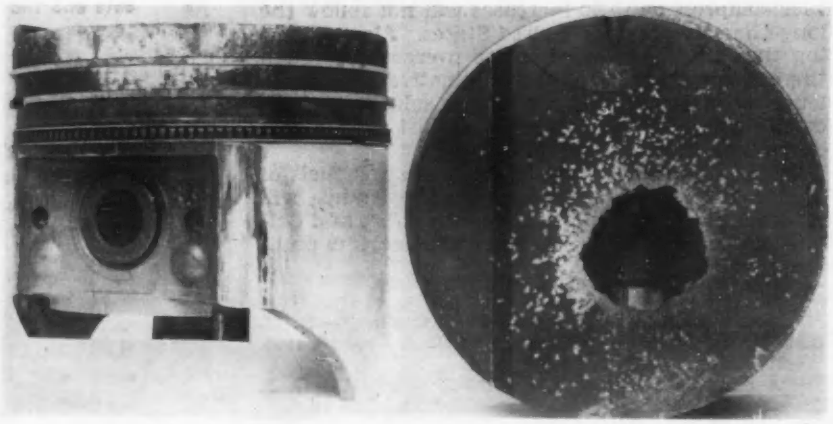

Fig. 6 — Piston failure due to abnormal combustion. (Lowther & Perry)

Table 1 — Valve Train Details — 1954

Tappet			Cam			Spring Load at Cam, lb
Material	Crown, In.	Coating	Material	Taper, Mins	Coating	Open
Chilled Cast Iron	Crown & Flat	Ferrox	Steel	12.5	Parco	237
Hardened Cast Iron	0.0025	Parco	Cast Iron	7	Parco	234
Chilled Cast Iron	0.002	None	Cast Iron	7	Parco	219
Chilled Cast Iron	0.004	Ferrox	Cast Iron	7	None	240
Carburized Steel	0.0015	Parco	Cast Iron	6.5	None	202
Chilled Cast Iron	Flat	Ferrox	Steel	None	None	216

(Ayres)

Table 2 — Engine Type Influences Lifter Wear

Oil	Engine X Chilled C.I.	Engine Y Steel	Engine Z Harden-able Iron
A	25	77	7
B	13	65	12
C	49	12	8
D	21	6	8

(Yowell)

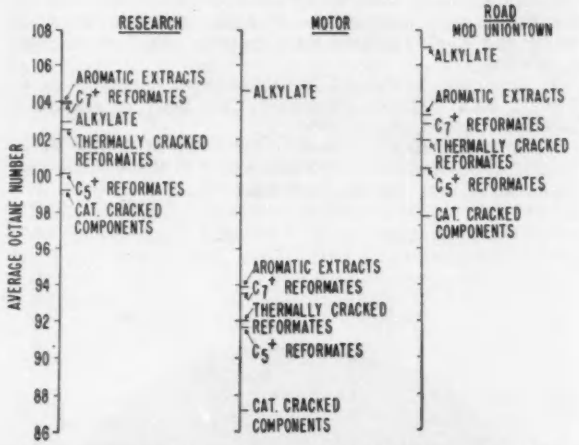

Fig. 7 — Average octane numbers of primary component group. (Greytak, Bellah & Morris)

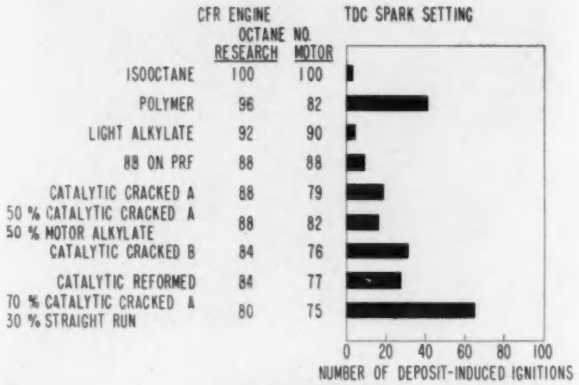

Fig. 8 — Ignition resistance of gasoline blending stocks. (Blaker)

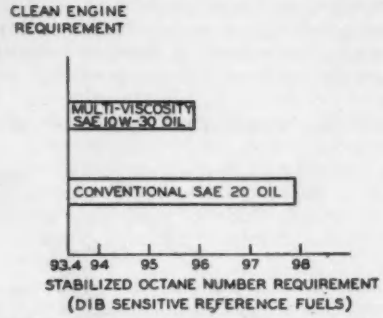
CLEAN ENGINE REQUIREMENT
MULTI-VISCOSITY SAE 10W-30 OIL
CONVENTIONAL SAE 20 OIL
93.4 94 95 96 97 98
STABILIZED OCTANE NUMBER REQUIREMENT
(DIB SENSITIVE REFERENCE FUELS)

Fig. 9 — Reduced ONRI with SAE 10-W-30 oil. (Lowther & Perry)

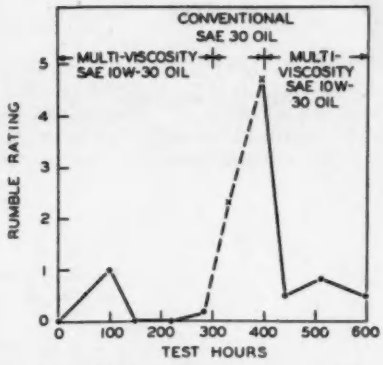

Fig. 10 — Reduction in surface ignition-induced rumble with SAE 10-W-30 oil. (Lowther & Perry)

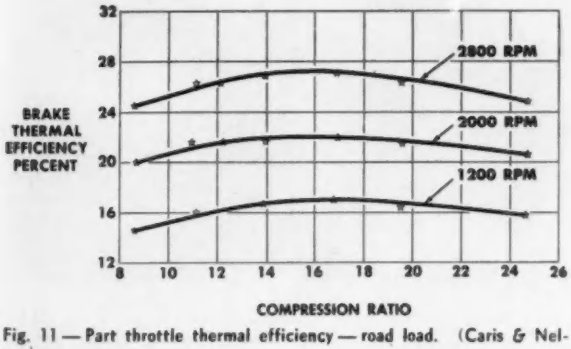

Fig. 11 — Part throttle thermal efficiency — road load. (Caris & Nelson)

cooperation in research

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revealed points of weakness and the need for increased anti-wear protection. A substantial contribution to information on service experience was obtained through an extensive cooperative field test[11] by a considerable number of automotive and petroleum laboratories involving one year's operation of 295 cars, followed by detailed examination of the key valve train components.

As in so many other wear studies, what is one metal combination's meat is another combination's poison. An example of this complexity is shown in Table 2[12].

Lubricant B, which gave excellent protection against wear with one type of lifter, chilled cast iron, was inferior in scuff protection with steel lifters, while Lubricant C gave exactly contrary results. Conflicting behavior like this has been observed with lubricants in which the active e-p agents consisted of sulfur and phosphorus used to form contaminating, adherent surface films, to prevent the welding of the highly loaded surfaces. These contradictions presented a quandary to lubricant marketers unable to segregate lubricants for individual car makes.

One answer to this problem of valve train distress was the elimination of the conflicting requirements presented by the different metallurgical combinations in use in the early '50s. One American car manufacturer, using a hardenable alloy iron camshaft and lifter combination, appeared to be an oasis of trouble-free service in an otherwise difficult area. Extensive investigations by automotive, oil, and additive supplier laboratories indicated this metallurgical combination to be much less susceptible to scuffing and less sensitive to oil and additive differences than other commercial combinations. At the same time, improvements in foundry "know-how" and technique resulted in wider availability, greater uniformity and lower cost of this material.

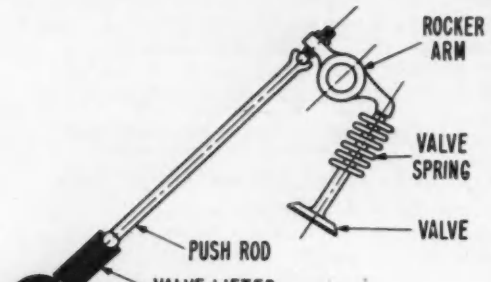

Fig. 12 — Valve train.

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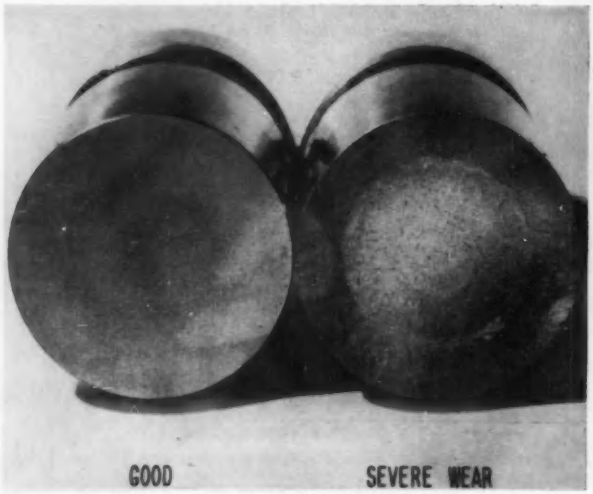
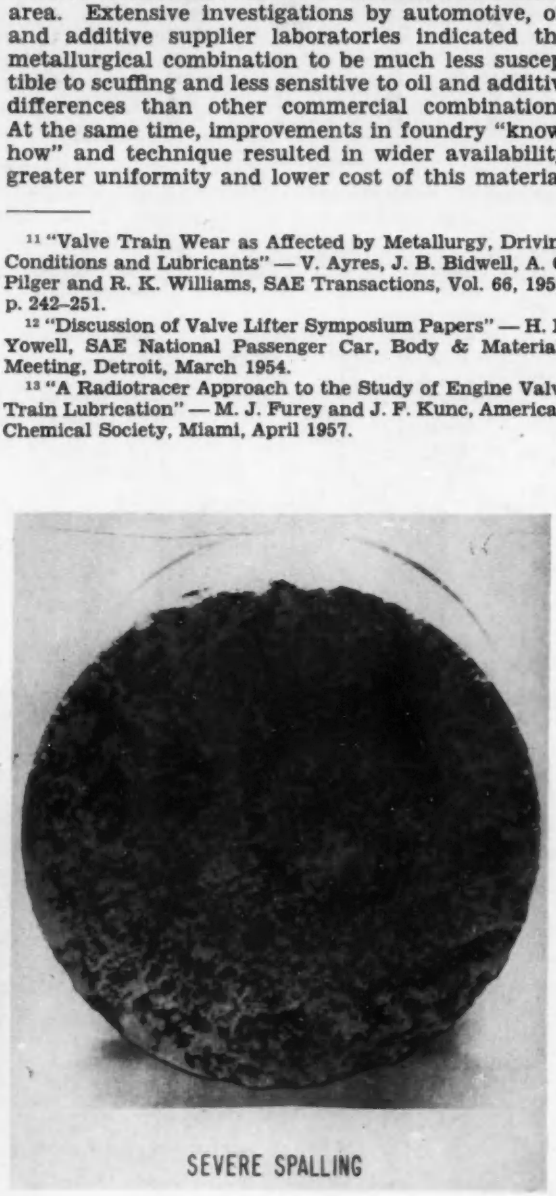
[11] "Valve Train Wear as Affected by Metallurgy, Driving Conditions and Lubricants" — V. Ayres, J. B. Bidwell, A. C. Pilger and R. K. Williams, SAE Transactions, Vol. 66, 1958, p. 242–251.

[12] "Discussion of Valve Lifter Symposium Papers" — H. L. Yowell, SAE National Passenger Car, Body & Materials Meeting, Detroit, March 1954.

[13] "A Radiotracer Approach to the Study of Engine Valve Train Lubrication" — M. J. Furey and J. F. Kunc, American Chemical Society, Miami, April 1957.

Fig. 13 — Sample valve lifters after use.





The result has been a fairly general although not unanimous adoption of hardenable alloy iron by the U. S. car builders. Concurrently, the oil marketers have moved toward greater uniformity in e-p additive through adoption of zinc dialkyl dithiophosphate by many oil marketers as an antiscuff agent.

This widespread adoption of a common metallurgical combination and a common e-p agent contains elements of danger. While this metal combination is relatively insensitive to wear and scuffing, when scuffing does occur the resultant loss of metal can be catastrophic. Therefore, there may be a definite ceiling to the use of this metallurgical and e-p additive combination.

This is illustrative of the inherent weakness in specifying materials rather than performance, thereby restricting freedom of design and hindering technological advances. While expedient in meeting an immediate problem, it is basically unsound from the long-range viewpoint. Performance rather than composition should be the basis for sound specifications.

Up to the present time, sulfur and phosphorus incorporated in organic chemicals have been used for the formation of the renewable contaminating surface films in situ, thereby replacing the protective coating which is removed under the high pressure rubbing action. The reactivity of the sulfur and phosphorus varies greatly depending on the strength of the intra-molecular bonds. Sulfur and phosphorus are the same elements which have been long used to protect hard alloy bearings, like copper-lead and cadmium-silver, against corrosive attack by forming a protective and passivating surface film. It should be noted that other metal salts of dialkyl dithiophosphoric acid are at least as effective as the zinc additive in reducing lifter wear[13].

Enhanced valve train wear protection is an area of obvious research toward higher capacity metallurgical and mechanical structures and more potent e-p additives which are compatible with each other. One important question is to what extent is chemical attack necessary for protection against destructive wear. It is possible that the application of solid state physics and the study of surfaces and molecular structures may resolve some of the present confusion in dealing with the behavior and interaction of surfaces. Isotopes or radioactive tracers used to tag additive components and thus permit the study of protective film formation and wear prevention is another tool. Another and newer means for investigating the chemical composition of surfaces involves the use of reflected protons.

The poet, Stephen Vincent Benet aptly said that "truth destroys truth." A new fact displaced an old one when the work with e-p agents demonstrated that a small change in concentration of an effective e-p agent could eliminate the effect of large differences in viscosity. This finding added further support to the advantages of light viscosity oils in reducing overall engine wear, including wear under low temperature conditions in particular. Such advances in engine oils make it possible to design engines for safe operation on lights oils, with resultant benefits to the car owner in fuel economy, performance and engine life.

It should be mentioned in passing that there is conclusive laboratory and large-scale service evidence that multi-graded oils are not deficient in wear protection compared to single viscosity grade oils.

Transmissions

Automatic transmissions (Fig. 14) and their fluids present different kinds of technical problems from those just discussed. In addition to having what may be the most complex combination of current requirements of any automotive or petroleum product,

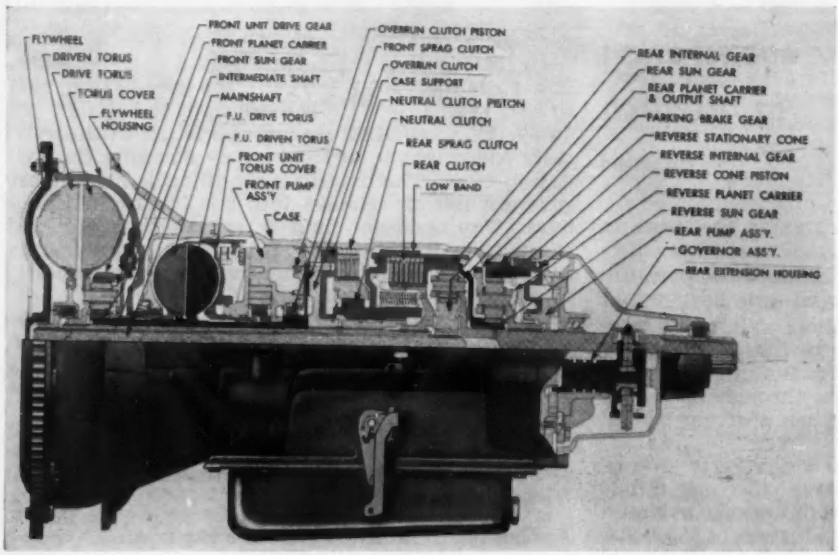


Fig. 14 — Automatic transmission.

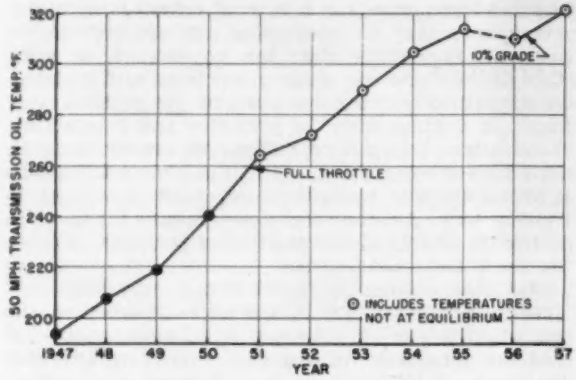


Fig. 15 — Transmission temperature trend. (Johnson & Mortensen)

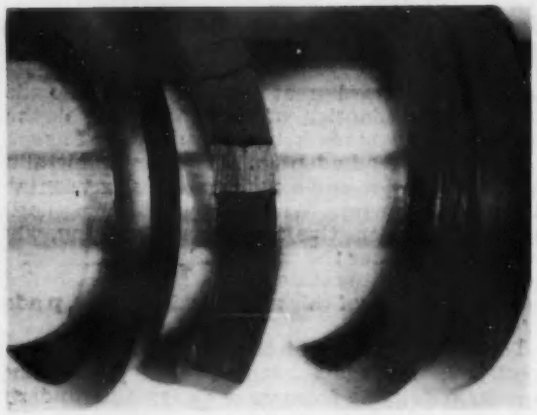


Fig. 16 — Deterioration of synthetic rubber transmission seal.

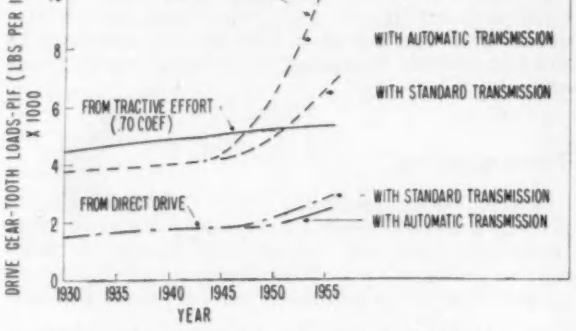


Fig. 17 — Axle drive gear tooth load trends. (Lewis & O'Brien)

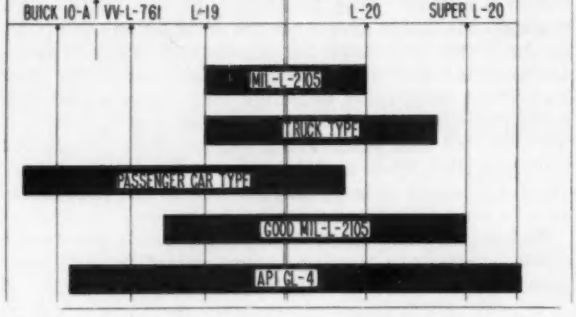


Fig. 18 — Gear lubricant performance in full-scale axle tests.

cooperation in research

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the future appears to offer a greater challenge in severity of automatic transmission operation. The most critical factor may well be high temperature stability under conditions of very intimate contact with air. At the same time, there appears to be a demand for wider viscosity range (flatter viscosity-temperature slope), greater shear stability (less loss in viscosity and viscosity index through use), and controlled lubricity for smoother shifting at all times.

Improved high temperature stability is a constantly recurring theme wherever petroleum products are discussed. In the case of automatic transmissions, where maximum temperatures of 350–400 F are easily obtained under stall conditions, it has been stated[14] that temperatures had risen considerably more than 100 F (56 C) in the decade from 1947 to 1957 (Fig. 15). This is more than 20 F (11 C) per two years, a temperature increase which is theoretically equivalent to approximately doubling the oxidation rate. The oxidizing condition is made more severe when air leakage into the transmission occurs. The resultant fluid deterioration is observed in the form of harmful deposits, viscosity and acidity increase, etc., leading to malfunction and a costly repair bill.

One American builder's answer to higher temperatures has been to halve the recommended mileage at which the fluid should be changed. Another way of counterbalancing the increase in temperature has

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[14] "Passenger Car Trends Affecting Fuels and Lubricants" — E. M. Johnson and C. W. Mortensen — SAE Annual Meeting, January 1958.

[15] "The Friction and Lubrication of Solids", etc. — F. P. Bowden and D. Tabor, Oxford University Press.

been through improvement in fluid stability. After base stocks of optimum stability consonant with other necessary properties have been selected, major emphasis is then turned to additives having anti-oxidant, anti-catalytic and other desirable abilities, particularly thermal stability of the additive itself.

New classes of additives may have to be invented if the ceiling on transmission operating temperatures is to be raised significantly. Also, more than one anti-oxidant may be required to cover the increased temperature range. At the same time, the new additives must not interfere with the effective functioning of the other fluid components required for satisfactory overall performance. Moreover, as temperatures are raised, it probably will be necessary to protect some of the other additives, such as the lubricity agents, against oxidative deterioration. Thus, this becomes a very complicated picture of chemical action and interaction.

The ultimate desire of the transmission designer and builder is a smooth, jarless, noiseless and consistently reliable shift under any and all conditions of operation. A very important factor is the reproducible nature of the clutch disc engagement. From the equipment standpoint, many variables, including the facing material, the shape of the plates and their grooving, etc., affect the shift, its reproducibility under varying conditions and the performance of different fluids. From the fluid standpoint, the term "controlled lubricity" has been used to describe a constant friction requirement.

Since the nature of friction and lubricity or oiliness is still only a theory, the solution to the problem of controlled lubricity has been largely along empirical lines, with only mediocre success to date. This is a problem to which the lubricant suppliers could devote worthwhile effort to add to the meager fund of basic information. It obviously is one of the most difficult areas of research since it deals with behavior of materials at surfaces, when the surface itself and its nature and the extent of its influence may be difficult to define quantitatively. Bowden and his coworkers[15], among others, have done valiant work but have only scratched the surface or slightly drawn back the curtain of understanding of the friction and lubrication of solids. This is an area where radioisotopes can be fruitfully employed to uncover the mechanisms involved.

Fluid viscosity is another element entering into the smooth shift objective, since it affects the performance of the actuating pumps and the rest of the hydraulic system. The ideal fluid for this purpose would be one of constant viscosity regardless of temperature or other conditions. Viscosity index (VI) improvers have been the means chosen to achieve improved viscosity-temperature characteristics. Since shear rates in an automatic transmission are relatively high and since long chain polymers, such as VI improvers, are susceptible to mechanical fracture under such shear conditions, the use of relatively shear-stable VI improvers is indicated. This is achieved currently by the use of lower molecular weight polymers which are more costly overall for a given effectiveness.

A great deal of new knowledge is being obtained in the field of intermediate and high polymers through the rapidly growing commercial importance of these materials in different industries. Some of this work is leading to greater specificity and control of chemical structure, even for materials of high molecular weight. Such efforts should contribute to a better understanding of the basic factors contributing to increased mechanical strength and stability, combined with the structural flexibility apparently required for effectiveness as a VI improver.

A commercial problem of considerable current and greater future interest due to higher temperatures is that of seals. Seals may easily be the most critical elements in the entire automotive drive line (Fig. 16). For want of proper seal protection against leakage, a transmission or an axle may be lost. The low cost elastomers used at present have a limited life under high-temperature conditions. New elastomers with superior high-temperature properties are available but at higher cost. The optimum solution to the seal problem will require the close cooperation of the car manufacturer, the seal supplier and lubricant manufacturer in obtaining adequate service experience and in developing significant performance tests. The SAE Fuels and Lubricants Technical Committee is taking a major role in coordinating cooperative activity on fluid and seal compatibility.

Axles

The hypoid axle is easily the hardest working and possibly one of the most neglected automotive components. It is far easier to deliver increased horsepower and torque to a rear axle than to build satisfactory durability into a critical unit confined by size and weight limitations. In addition to higher en-

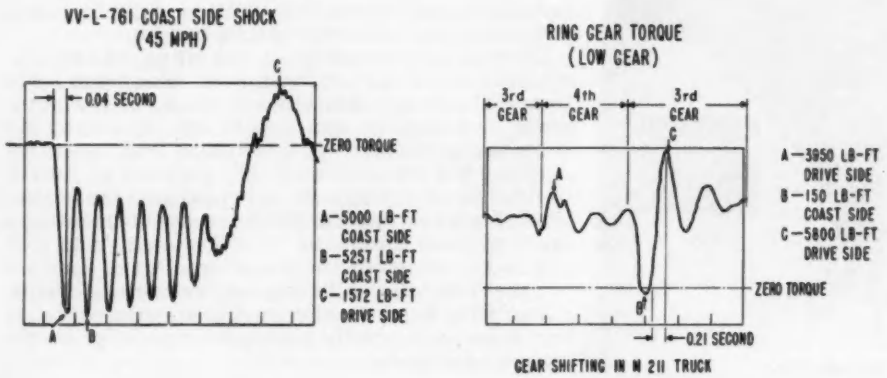

Fig. 19 — Dynamic ring gear torque. (Powell & Barton)

cooperation in research

. . . continued

gine horsepower and automatic transmissions which have greatly increased low gear loading (Fig. 17)[16], the higher pinion offset has produced more sliding motion between the gears.

Lubricants thus have become a limiting factor in the load-carrying capacity of American axles[17]. The lead soap-active sulfur lubricants had satisfactory anti-score protection under high speed passenger-car conditions but were deficient in vital bearing protection and in high torque characteristics. The truck type and older multi-purpose type lubricants had good anti-wear and high torque characteristics but were deficient in anti-score protection at high speed.

The current answer to this problem is a new type of multi-purpose axle gear lubricant with excellent anti-score protection under both high speed and high torque conditions and with good anti-wear properties (Fig. 18). The active elements in the new products are sulfur, chlorine and phosphorus which, as in the case of the e-p agents in engine oils, act as potent anti-weld materials by chemically forming contaminating surface films which are strong in compression and weak in shear.

Axles will have a harder, rather than an easier, job in the future. In some cases, the axle may be the key to the design of the entire vehicle. This is being recognized by the expansion in technical manpower and test facilities assigned to axle research and development, including full-scale axle installations in the laboratory and increased road and proving ground tests. However, there are some problems which may require the assistance of basic research effort. Thus, more work is being directed along theoretical and mathematical lines to analyze gear stresses under dynamic conditions. Due to the unsteady nature of the power plant and the axle load, the dynamic loads on the gear teeth can be very much greater than the loads computed on a constant torque basis (Fig. 19)[18].

Temperature level again is an extremely important factor in axle performance. While some American builders and lubricant suppliers state that bulk oil temperatures in excess of 250 F are detrimental to gears, bearings, seals and lubricants, the temperature load in some cases is becoming greater than desirable with current products. New gear steels having higher hot strength and less subject to surface decarburization and annealing at temperatures above 250 F may be required. The lubricant suppliers will have to find a way to combine excellent anti-weld activity with better thermal and chemical stability at high temperatures. This latter goal will undoubtedly require completely new knowledge and a break-through into new areas of information.

There is need for basic research on mechanisms of gear surface protection, including information on the change in surface condition and chemical activity level during and after break-in, and the cause and effect of higher temperatures. Here again, the use of radioactive tracers may prove to be an invaluable tool in studying additive transfer and film formation. The application of solid state physics to adhesion of materials and knowledge of surface and molecular structure and activity should be helpful.

The new limited-slip axles (Fig. 20) present an additional problem similar to one of the automatic transmission problems. This is the need for controlled lubricity to effect smooth engagement and minimize "stick-slip" action between the clutch plates which results in objectionable "chatter" and noise. Lubricity agents that minimize "chatter" apparently reduce the effectiveness of the anti-weld agents, introducing an element of conflict and compromise which adds emphasis to the need for new research and basic information on the lubrication and friction of solids. It is probable that new test techniques for evaluating friction characteristics and "stick-slip" behavior will be helpful.

There is a development in the offing, known colloquially as "traxle" or "transaxle" which will serve to accentuate the individual problems of the automatic transmission and hypoid axle by combining these in one package. It is fortunate that recent experience has demonstrated that viscosity as such is of little or no significance in hypoid axle protection. This eliminates one hurdle to the development of a multi-purpose automatic transmission-hypoid axle lubricant. However, the major problem of combining the currently conflicting requirements of chemical activity for anti-weld protection with oxidative and thermal inactivity for high temperature stability are highlighted.

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[16] "Rear Axles-Today-Tomorrow" — R. P. Lewis and L. J. O'Brien SAE Transactions, Vol. 66, 1958. p. 364–381.

[17] "New Horizons With New Gear Lubricants" — L. Raymond, SAE National West Coast Meeting, August 1957.

[18] "Investigations of Dynamic Loadings of Automotive Hypoid Gears" — D. L. Powell and H. R. Barton, SAE National Fuels & Lubricants Meeting, November 1957.

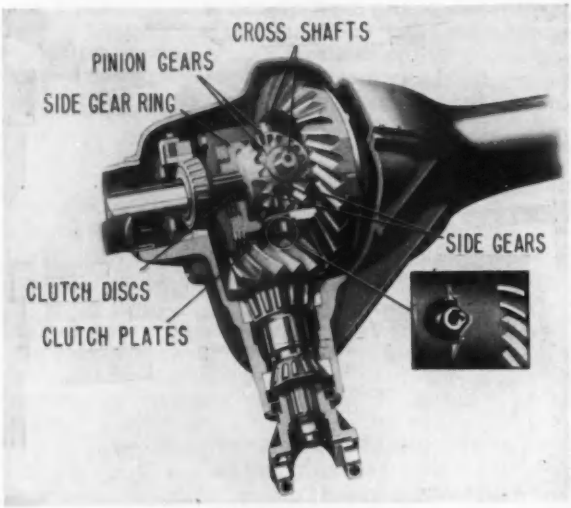

Fig. 20 — Limited-slip axle.

Designing Strength into Agricultural Drive Lines

Based on paper by

Martin A. Erickson

Tractor & Implement Division, Ford Motor Co.

PROGRESS made in measurement of drive line loads — as well as of structural service loads — parallels the greater usage problems which have arisen on agricultural drive line units. Knowing the drive line loads, the engineer now finds it possible to set up simulated loading conditions in the laboratory and evaluate the working stress of the parts under consideration.

Experience with these strength analysis studies shows they result in sound structures and accelerated development time. Also, unnecessarily large factors of safety need no longer be used.

Measurement of drive line loads

In measuring drive line loads today, the drive lines are usually loaded in torsion . . . or a combination of bending and torsion.

These loads as a rule can be very conveniently measured by means of wire resistance or foil-type strain gages. For torsion the axis of the gage is oriented at 45 deg to the axis of the shaft, while for bending the axis of the gage coincides with the longitudinal axis of the shaft. The strain signal is brought out to a stationary point by means of a commutating device such as brushes and rings or a metal disc rotating in a confined volume of mercury.

Occasionally, it is possible to measure torque or bending indirectly by making strain measurements on a reaction member. For example, we have obtained the torque in the axle shaft of a tractor while plowing, by measuring strains in the axle housing using strain gages.

Torque values in drive lines are also obtained from dynamometer testing using the reaction force on load absorbing devices such as generators, water brakes, and prony brakes as the measuring device. Driving devices such as electric and hydraulic motors, in which the input power and efficiency are known, can also be used to measure the torsional forces in drive lines.

Undoubtedly, the strain gage torquemeter and associated recording equipment constitute the most acceptable method for measuring torques in agricultural drive lines under field operation.

In the case of field tests, the torque signal is recorded by means of a direct writing or optical-type oscillograph mounted in an instrument truck or "Travelab," as it is more frequently called. Five conductor shielded cables 30 ft long are used between the slip-ring or strain-gage terminal block mounted on a stationary member near the gage and the connector panel of the Travelab. The Travelab is a four-wheel-drive unit powered by a 6-cyl 140-hp engine, enabling it to negotiate almost any type of field condition. The instrumentation is powered by a 1500-w 2-cps 110-v 60-cps engine-generator unit when operating in the field. It has facilities to connect to any current for stationary or laboratory testing. In addition to the instrumentation, the Travelab contains tools and supplies sufficient to make any electrical or mechanical repair.

A typical field application is shown in Fig. 1. In this case horsepower necessary to operate the twin rotary cutters under different crop conditions was

STRENGTH is of major importance in any drive line. Provision must be made to accommodate the maximum forces that can be applied. . . .

Experimental strength analyses can result in sounder structures — and in accelerated development time.

Designing Strength into

Agricultural Drive Lines

. . . continued

required. Torque and speed measurements were taken from a pto extension torquemeter (Fig. 2). The drive shaft of a standard pto extension was modified to incorporate coined silver slip rings connected in a strain-gage bridge cemented to the shaft. The electrical connections to the output plug were made through copper brush assemblies incorporating silver graphite brushes. The speed indication was obtained from an inductance pickup, which produced a pip indication on the oscillogram for every revolution of the shaft. From a count of the pips, during a time interval as established by the oscillogram speed, the drive shaft speed is computed. Thus, with speed and torque data, available horsepower input to the machine can be determined.

Typical drive line strength problem

During early stages of development of a rotary cutter design for Ford's 60-in. tractor, Ford engineers recently found themselves faced with a typical drive line strength problem. Areas around the flanges of the gearbox were found critically stressed when encountering stones and stumps. So, an experimental stress analysis was made.

Results of an outdoor Stresscoat test operating over stones revealed areas of weakness in the gearbox casting (see Fig. 3). SR-4 strain gages were attached at critical corners of the gearbox lower housing flange for measuring the stress level under field operation. A pto torquemeter was also installed. Fig. 4 shows a typical Brush oscillographic record taken while passing over stones in second gear at 2000 engine rpm at about 4¾ mph. It will be noted that a maximum torque of 1370 ft-lb was measured on the pto shaft. The static slipping torque of the pto was 650 ft-lb established by the tractor clutch torque capacity. Stresses measured in the gearbox were 19,000 psi in tension, which was too high for repetitive loading on cast iron having 30,000-psi tensile strength.

After the evaluation of the working stresses and torques encountered, an analysis was made of the allowable stresses which could be withstood by the gearbox casting as well as the drive train. Results indicated a reduction of the working stresses must be made. It was reasoned that this could be done by cushioning the load. A friction Morse type torque limiting clutch was selected as a means of obtaining this cushioning effect (see Fig. 5). Subse-

Fig. 1 — Typical drive line torque measurement test on 109-in. rotary cutter.

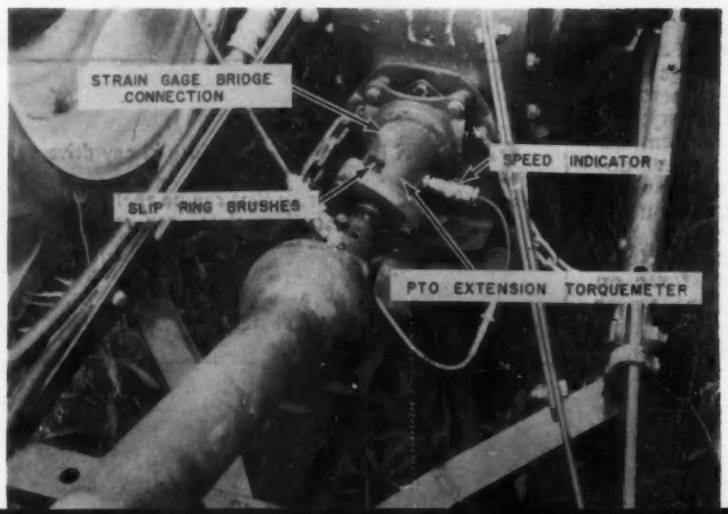

Fig. 2 — Application of pto extension torquemeter drive train power measurements.

quently, the field runs were repeated with the torque limiting clutch set at a static torque of 240 ft-lb. Fig. 6 shows the records obtained and the measured values computed. It was obvious that a considerable reduction was made in drive shaft torque resulting in a reduction of working stress in the gearbox housing. This torque limiting clutch was released for production and has been used in our machine ever since.

Maximum torques obtained were approximately equal to twice the static capacity of the drive. For example, slipping the foot off the clutch pedal while the tractor engine is running at 2000 rpm gave a torque peak of 1185 ft-lb, nearly twice the drive line torque capacity through the tractor clutch (615 ft-lb).

Also, the maximum torque with the limiting clutch in the drive line gives a value of 670 ft-lb, a little better than twice the limiting clutch static capacity of 300 ft-lb.

It is also interesting to note that Ford's 800 series tractor driving its rotary cutter can deliver over 400 ft-lb torque at the pto shaft. In spite of the torque limiting clutch setting of 300 ft-lb, a sudden stall load will kill the tractor engine in a matter of seconds. The sudden buildup of dynamic torque is apparently of sufficient magnitude to pull the tractor engine down quite rapidly.

To evaluate the strength of the tractor pto shaft it was decided to run a series of fatigue tests. Fig. 7 shows the laboratory fixture used to test the pto shaft specimens. This fixture is attached to one of our standard bed plates. The loading is accomplished by prestressing the two shafts in torsion up to a torque value one-half that of the maximum to be tested and locking them at that load by means of the lever and clamping fixture shown at the right of the machine.

The test results obtained from Ford's latest production pto shaft are shown in Fig. 8.

A further strength consideration on the rotary

Fig. 3 — Stresscoat indications showing critically stressed areas of rotary cutter gearbox.

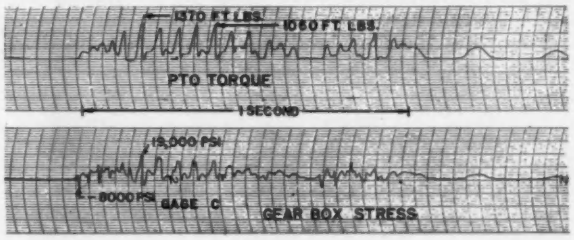

Fig. 4 — Typical Brush oscillographic record taken while rotary cutter was passing over 6-in. stones in second gear at 2000 engine rpm at about 4¾ mph — no torque limiting clutch.

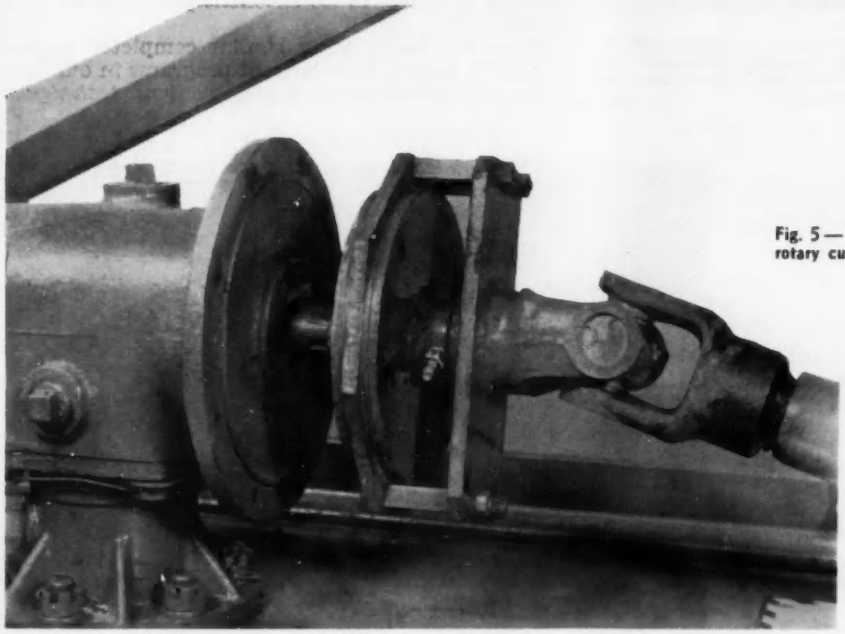

Fig. 5 — Torque limiting clutch for rotary cutter drive train.

Designing Strength into

Agricultural Drive Lines

. . . continued

cutter drive line is the bending stress produced in the gearbox input shaft due to vertical, lateral, fore-and-aft and torsional accelerations as the cutter blades contact obstacles or are lowered down on obstacles such as stones and small saplings. In the case of our 60-in. cutter two SR-4 strain gages were mounted on the input shaft in the longitudinal axis, one on top and one on the bottom, to measure bending. These gages were connected through a slip-ring assembly mounted on a rear drive shaft extension of the cutter gearbox. In addition, accelerometers were used to measure accelerations for the various modes of gearbox travel. Torsional loads were measured on the pto torquemeter built into the standard pto extension.

Many runs were made under a variety of field conditions where stones, stumps, and rough terrain were encountered. Measurements of torque, bending and acceleration were made by means of the Travelab and associated equipment.

Following the field load measurements a rotating bending fatigue test program on the rotary cutter gearbox input shaft was undertaken in the laboratory.

At the completion of these tests the strength analysis was made on the basis of the maximum torque and bending moment occurring simultaneously. It can be noted (Fig. 9) from the oscillogram taken when dropping the cutter on rocks that the input torque varies from 0 to some maximum value (top trace). At the same time the bending moment on the shaft is varying from positive to negative values (bottom trace). Fig. 9 lists some of the torsional and bending moments obtained as well as the calculated stress values derived from these measured data. The combined stress values were obtained using the distortion energy theory of failure.

$$S = \sqrt{S_b^2 + 3S_s^2}$$

where:

S = Equivalent direct stress, psi
S_b = Bending stress, psi
S_s = Shear stress, psi

Life expectancy values are obtained from the allowable stress — limited life curve shown at the left of Fig. 9.

Under most field conditions it was apparent that the drive line strength was adequate on the experimental machine. To take care of the border line case, when dropping the cutter on rocks, the critically stressed snap-ring groove section of the gearbox input shaft was strengthened by increasing the diameter sufficiently to ensure adequate service life. This modification in the drive line as well as other modifications resulting from the experimental stress analysis of other structural members of the machine were incorporated into prototype models used in field testing.

Subsequent field testing proved the reliability of the experimental stress analysis techniques. The rotary field cutter has been used now for over five years with virtually trouble-free operation. Many reports have been received from all parts of the country attesting to its excellent performance and durability.

There are many other similar completed implement and tractor development programs in our files where experimental *strength analysis techniques*

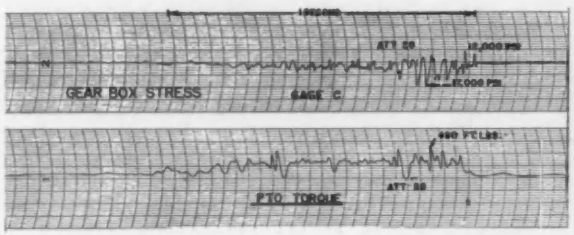

Fig. 6 — Records obtained and measured values computed in analysis of allowable stresses which could be withstood by gearbox casting and drive train — torque limiting clutch, set at 240 ft-lb static, 2000 engine rpm, second gear, passing over 6-in. stones at 4¾ mph.

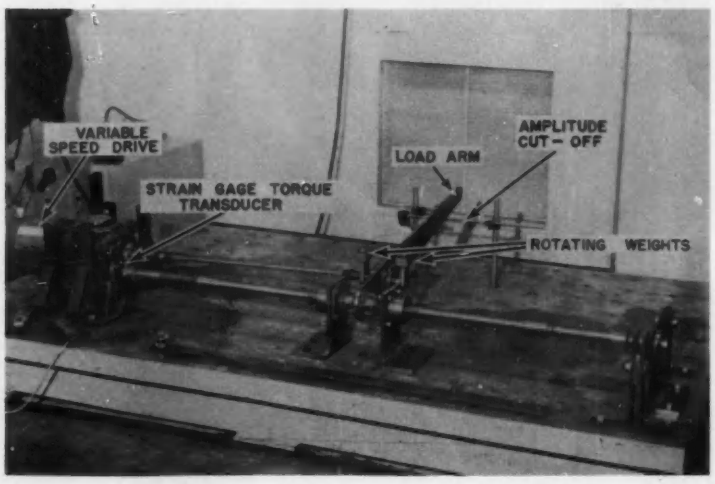

Fig. 7 — Pto shaft fatigue text fixture.

have not only *resulted in sound structure* and *accelerated development time*, but also have improved the company's competitive position. This is brought out not to praise our efforts but primarily to demonstrate that in this day and age with modern instrumentation and procedures it is no longer necessary to estimate loads and behavior of material. We have attempted to show the field loads can be measured as to magnitudes and frequency of occurrence under any type of service condition. With this information, prototypes can be stress analyzed by experimental techniques and working stresses evaluated. Allowable material stress is then determined by physical and fatigue testing and compared with the measured working stress as determined by measurement to obtain the margin of safety. At this point all necessary design modifications are made.

There are several advantages arising out of using these experimental techniques, namely:

1. Products can be developed in a much shorter period of time than that possible by procedures used heretofore.
2. Weight and consequently cost are reduced due to optimum distribution of structural material.
3. Designers receive more useful information to assist them in making design modifications and in designing future machines.
4. Laboratory personnel gain information that will help them to standardized loading and testing conditions for the present as well as future machines. This will include establishing laboratory procedures and acquiring the necessary laboratory equipment.
5. Service problems can be quickly and effectively analyzed and solved with experimental strength data.

It must be pointed out here that field testing must also be included in a development program. Field testing under various conditions must be carried out to evaluate performance. Laboratory structural testing assists the field test program in that failures of operating parts will be very much decreased, thus allowing field test crews more time for concentrating on the functional characteristics of the machine.

To Order Paper No. 95U ...
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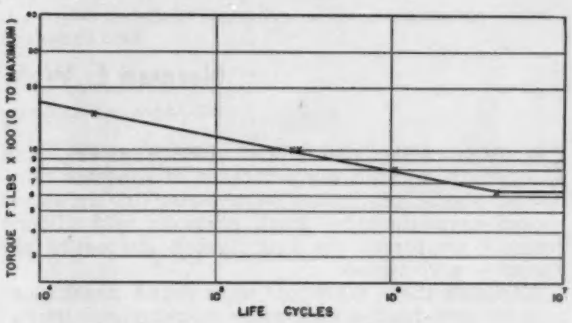
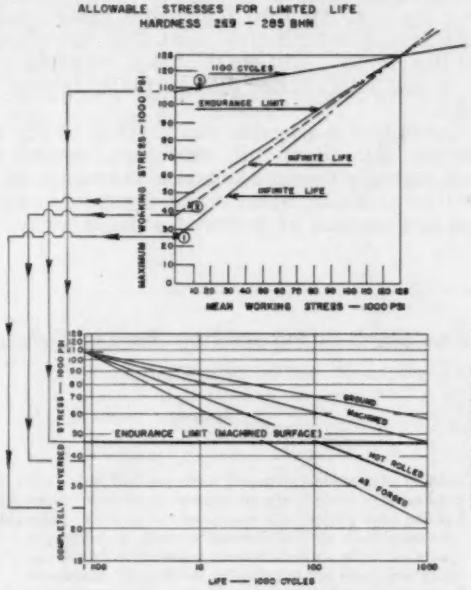
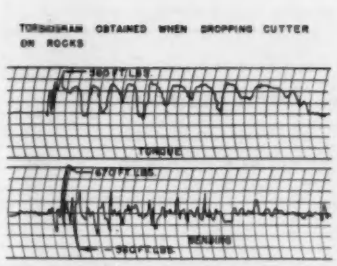


Fig. 8 — Torsional fatigue test data on induction-hardened pto shaft.





NO.	OPERATION	TORQUE		BENDING		EQUIV COMBINED STRESS-PSI	LIFE EXPECTANCY
		TORSIONAL MOMENT FT. LBS.	SHEAR STRESS PSI	BENDING MOMENT FT. LBS.	FIBRE STRESS PSI		
1	CUTTING HEAVY WEEDS	0 TO 85	0 TO 4,488	- 177 177	- 25,300 25,300	- 25,300 25,300	INFINITE
2	CUTTING INTO ROCKS	0 TO 339	0 TO 18,700	- 210 210	- 29,700 29,700	- 29,700 44,000	INFINITE
3	DROPPING CUTTER ON ROCKS	0 TO 540	0 TO 33,900	- 560 670	- 78,000 94,000	- 78,000 110,000	1100

Fig. 9 — Rotary cutter input shaft life expectancy determined from oscillographic recordings.

Asbestos–Reinforced Plastic Hold Strength at High

Based on paper by

Norman E. Wahl

Cornell Aeronautical Laboratory

EROSION AND ABLATION RESISTANCE, and strength at high temperatures of asbestos-reinforced plastic laminates were tested in simulated rocket environments. Both phenolic and silicone resins — reinforced by long-fibered chrysotile asbestos — were tested.

Although these materials were found unsatisfactory for very-high-temperature rocket engine conditions, phenolic asbestos showed possibilities as nose cone material. . . . And, silicone asbestos appeared feasible for rocket bodies or structural components that would be subjected to 800 F for long periods of time.

During the tests, it was determined that the composite must be molded at pressures above 200 psi for optimum properties.

Rocket engine conditions

Phenolic asbestos and silicone asbestos specimens were exposed to a high-velocity gas exhaust at three temperatures having varying percentages of oxygen to simulate rocket engine conditions. Table 1 shows the test conditions and Table 2 some typical results. Temperature seems more critical than the percentage of oxygen in the thermal degradation of these laminates. Neither material was satisfactory for rocket engine applications due to the amount of material eroded from these specimens. The phenolic asbestos specimens showed considerably lower weight loss due to erosion than the silicone asbestos.

Nose cone conditions

The ablation tests were conducted with a high-temperature resistance heater which could introduce up to 65 kw into a nitrogen gas stream; produce initial calorimetric heat flux densities up to 550 Btu/ft²-sec; and obtain mass velocities up to 40 lb/ft²-sec with choked flow normally existing at the exit.

The phenolic asbestos was superior to the silicone asbestos for short-time exposures under varying heat fluxes. Phenolic asbestos showed more resistance to ablation, based upon depth of penetration and the amount of material ablated away. Fig. 1

Table 1 — Test Conditions

	I	II	III
Combustion Temperature, R	4820	4060	3260
Excess Oxygen, %	5	15	20
Calculated Exhaust Gas Velocity		Mach 2.6	

Table 2 — Asbestos-Reinforced Laminates — ½-In. Thick — Exposed to Rocket Exhaust

Type Resin and Specimen No.	Leading Edge Radius, in.	Test Condition	Time Exposed, sec	Loss in Weight, g/sec	Remarks
Phenolic 26	9/32	I	20.8	1.9	Leading edge eroded irregularly back one-half inch. Sides ablated.
Phenolic 27	9/32	II	28.0	1.7	Leading edge eroded back one-quarter of an inch. Sides ablated.
Phenolic 28	9/32	III	20.3	1.4	Leading edge eroded back one-quarter of an inch. Sides ablated.
Silicone 73	1/4	I	6.6	7.6	Specimens badly ablated showing tendency to delaminate.
Silicone 74	1/4	II	6.5	5.0	Specimens badly ablated showing tendency to delaminate.
Silicone 75	1/4	III	5.8	6.1	Specimens badly ablated showing tendency to delaminate.
Silicone 76	5/16	II	3.5	7.6	Specimen showed almost no pyrolysis — considerable delamination of outer plies.

Laminates

Temperatures

Fig. 1 — Wedge-shaped specimens after 15-sec ablation test.

compares phenolic asbestos to silicone asbestos after 15 sec exposure to gas temperatures of approximately 4000 F. Graphic comparison of depth of penetration of ablation of silicone and phenolic wedge-shaped specimens as a function of time is shown in Fig. 2. Typical comparative loss in compressive strength of the residual non-ablated material is shown in Table 3.

Long exposure to rocket body temperatures

Losses in weight and strength at temperatures up to 1000 F were measured for periods up to 192 hr. Fig. 3 compares the weight loss of phenolic asbestos and silicone asbestos laminates after 3-hr exposure. Assuming that a 2% weight loss is the maximum desirable, this shows that the corresponding temperature for silicone asbestos is 700–800 F, and for phenolic asbestos 500 F.

These temperatures were used for further evaluation of mechanical properties of these two types of laminates. Exposure was arbitrarily selected as ½ hr and 192 hr. Tables 4–6 summarize these test results. It can be seen that silicone asbestos laminates maintain a high percentage of their mechanical properties up to 800 F.

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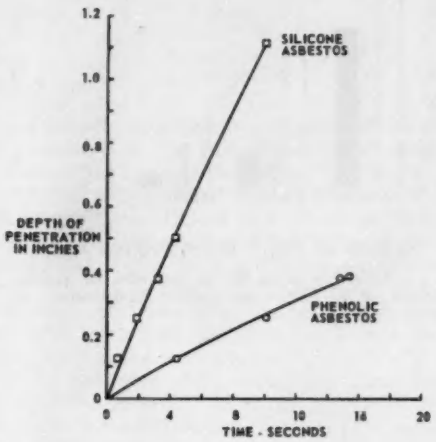

Fig. 2 — Depth of penetration of ablation front versus time.

Table 3 — Ultimate Compressive Strength Before and After Ablation Tests

Control	Phenolic Asbestos, psi	Silicone Asbestos, psi
Before Test	24,900	12,700
	24,200	12,800
	25,300	13,600
	24,200	14,000
	24,600	13,300
Average	24,600	13,300
After Test	18,400	8,200
	14,100	8,300
	16,400	8,700
Average	16,300	8,400

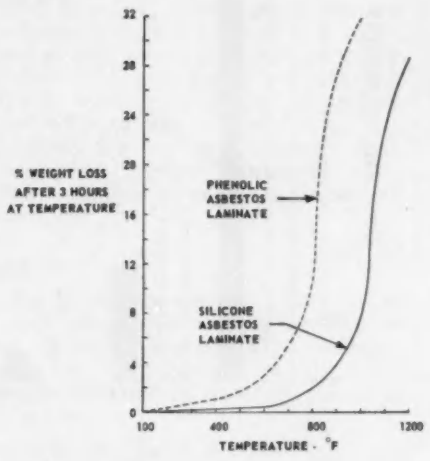

Fig. 3 — Weight loss of asbestos laminates after 3-hr exposure.

Anti-Icing

. . . reduce car stalling, recent tests show.

Based on paper by

R. E. Steinke, California Research Corp. and

H. W. Sigworth, Standard Oil Co. of California

ADDITIVES CUT the incidence of stalling by two-thirds during an extensive series of field tests last winter. When the 90 cars tested used a normal production gasoline having a 50% point of 206 F, stalling occurred in 43% of the observation periods . . . under the atmospheric conditions most conducive to icing (40 F ambient and 100% relative humidity).

When stalling occurred, the average number of stalls per observation period was 1.7. Most of the 1949-through-1958 models involved stalled once or twice . . . and only a few as many as four times. Some makes of cars appeared more prone to stall than others, and more stalling was encountered with manual than with automatic chokes.

These field test data were gathered by 90 car owners during normal driving, including to and from work. The test cars were so chosen that they would approximate those existing in both the Canadian and American car population. Because stalling from carburetor icing usually occurs at idle, the drivers were requested to establish a uniform pattern in stopping at stop signs . . . and each driver was asked to record only those stalls occurring between the first 10 min of operation following a cold start.

All data, including weather information, were put on computer cards to permit analysis of the tremendous quantity of data obtained.

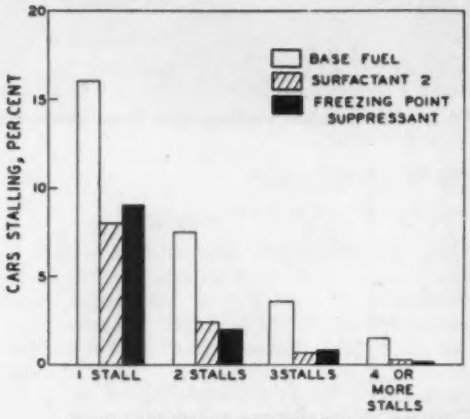

Fig. 2 — Pattern of stalls for all motorists for relative humidities of 81-100% and ambient temperatures of 15-60 F.

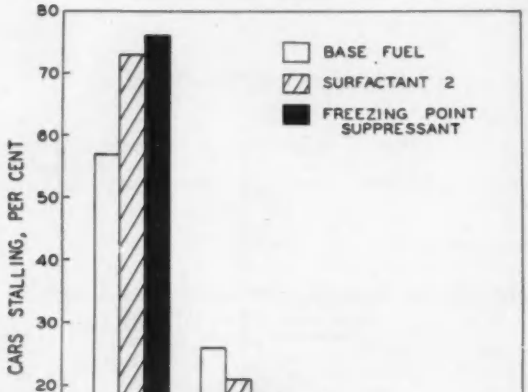

Fig. 3 — Pattern of stalling for those motorists who experienced one or more stalls.

Field test data

The comparison of the base fuel, two different surfactants, and a freezing-point suppressant in Fig. 1 shows that stalling is greatly dependent on relative humidity and ambient temperature. The critical temperature for icing falls between 30 F and 50 F ambient temperature with the extreme range being about 25 F and 60 F.

Below 25 F very little moisture is contained in the

Additives

Computer analyzes data.

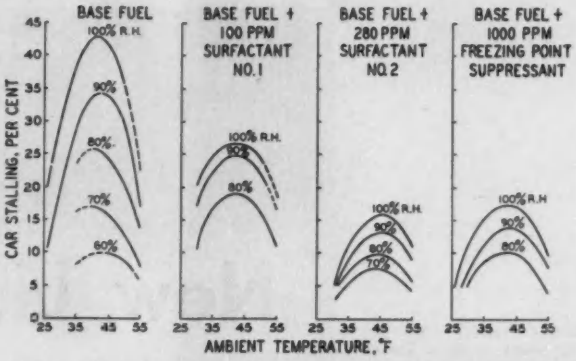

Fig. 1 — Effect of relative humidity and ambient temperature on car stalling . . . stalling, in this case, being defined as "the percentage of test cars encountering one or more stalls during the 10-min observation period following a cold start."

air even at high relative humidities, and above 60 F the refrigerating effect of the gasoline is not great enough to cause icing.

A concentration of only 100 ppm of surfactant No. 1 was quite effective in reducing stalling. Surfactant No. 2 was even more effective, but it was tested at almost three times the concentration. Surfactant No. 2 was as effective as the freezing point suppressant at one-fourth the concentration.

The number of cars stalling at critical icing weather conditions was much higher than expected. For example, at 100% relative humidity and 40 F ambient temperature, 43% of the test cars experienced stalling one or more times when warming up on the base fuel.

Some stalling from causes other than icing would be expected with a 120-car test fleet. For example, 3% of the cars stalled when using a fuel containing 280 ppm of surfactant No. 2 at relative humidities less than 60%. These stalls can be classed as mechanical stalls, but the percentage is too low to be considered in the analysis. Although a large percentage of the test cars stalled on the base fuel, the number of stalls experienced by the cars encountering stalling during the 10-min observation period averaged only 1.7. As is shown in Fig. 2 for the conditions of 81–100% relative humidity and 15–60 F ambient temperature, only a few cars stalled more than once or twice on the base fuel. Use of additives in every case reduced the number of cars stalling over 50%, and less than 5% stalled more than one time per observation period.

Fig. 2 data are for all cars on test. Fig. 3 is a similar plot except that only those cars encountering stalling are considered.

Fig. 3 shows that from one-half to three-fourths of the cars that stalled, only stalled once. The majority of the remaining cars stalled only two or three times with an average of only 2% stalling more than three times. Fig. 3 also shows, unexpectedly, that no large reduction in the percentages of multiple stalls during each observation period occurred with the use of additives. Thus, even though additives greatly reduced the number of cars experiencing stalls, they did not appreciably affect the overall multiple stalling pattern. Although the drivers generally experienced only one or two stalls per observation on a critical day, these stalls were apparently quite noticeable. Motorists who drive over a particular route daily are quite sensitive to stalling occurring at approximately the same places on critical days. By the end of the test, many of the drivers of those cars that did stall were able to tell which fuels contained additives and which did not.

Cars equipped with automatic chokes were found to stall much less than those equipped with manual chokes. The difference in stalling is possibly due to the effect of the fast idle mechanism since the tendency may be to use the manual choke for a shorter period of time. On the other hand, driver education on extended use of the manual choke during the critical icing period could, because of the faster idle, completely eliminate stalling.

Carburetor type may also have had an effect on stalling tendencies. One- and two-barrel carburetor engines performed similarly, but engines with four-barrel carburetors stalled only about half as much as those with one- and two-barrel carburetors. (The cars equipped with four-barrel carburetors were also equipped with automatic chokes.)

The stalling trends for cars of different year models were also studied. Although there was considerable variation from year to year, no significant trend could be observed.

Additives indicated

Use of gasoline additives to control icing can be achieved at low cost and should be used when there is a definite need. Whether this corrective measure is adopted is a matter of judgment based on an evaluation of weather conditions and fuel volatility in each marketing area.

To Order Paper No. 86V . . .
. . . on which this article is based, turn to page 6.

New Linkage System for Harrows

. . . offers flexibility of operation and demonstrates

Based on paper by

D. F. Kampe

University of Illinois

A NEW LINKAGE system between tractor and mounted or semimounted harrow allows the individual harrow gangs to follow irregular ground contours and reduces the tendency of the blades to break because of the restricted movement characteristic of the rigid hitch. The system retains the features of transportability and depth control.

The system consists of two offset links extending back from the lower corners of an A frame and attaching to the front of the harrow frame (Fig. 1). These free-ended links allow the front of the harrow to rise or fall without requiring a change in the A frame position. They also allow the A frame to rise and fall with the tractor without moving the harrow. In addition to the lower links, there is a top strut from the top of the A frame to the rear of the harrow to control the forward pitch of the harrow and to lift the rear in transport.

In the side view this system of links becomes a 4-bar linkage with the A frame and harrow being the primary members. The lower links acting together and the top strut form the connecting links.

Wheel-mounted system similar

In the design of the semi- or wheel-mounted harrow, an independent carrier is made to provide the lift and transfer the pull from the drawbar to the harrow. A harrow frame, similar to that used on the tractor-mounted harrow, is used to connect and hold the gangs in place. These two basic elements are connected by a linkage system utilizing the same principles as the tractor-mounted type.

To provide better following of the ground contour in the wider widths, the harrow frame is made in two halves with a longitudinal joint down the center. Each half has its own linkage system connecting it to the main carrier and is connected to the opposite half by the longitudinal joint.

In the plan view, all the links on the wheel-mounted harrow converge toward the drawbar clevis

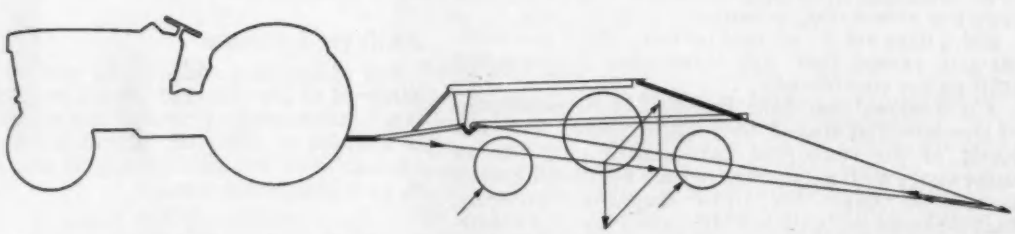

Fig. 2 — Analyses of motion and force show how forces combine in the wheel-mounted harrow. Carrier wheels can be used for gaging by controlling direction of force line.

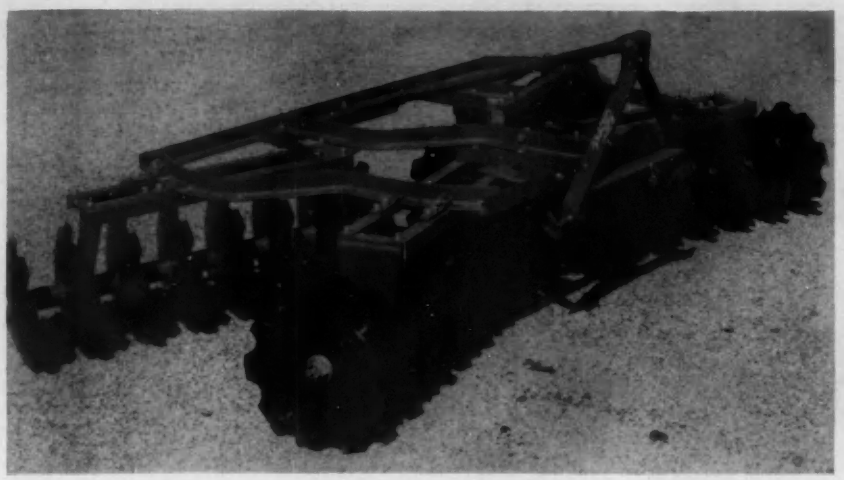

Fig. 1 — Tractor-mounted harrow with A frame divorces motion of tractor and harrow so that individual harrow gangs can follow ground contours freely.

its potential for transmitting forces

pin. This cuts down on side motion in the links on turning. It also helps to keep the carrier frame narrow yet keep the attachment points for each linkage system near the balance line for each half of the harrow frame. The center balance springs are then able to control the roll of the two halves in transport.

How forces are transmitted

The motion and force analyses (Fig. 2) in each of the linkages is similar to analyses for the tractor-mounted type. The carrier performs the same role as the tractor lift links and A frame. The carrier wheels can be used for gaging by controlling the direction of the force line, as is done with the tractor-mounted type.

When the carrier wheels are lifted free from the ground the weight of the carrier frame can be transferred to the harrow frame through the links as a vertical force in combination with the drawbar force from the tractor (Fig. 3). This changes the direction of the force transmitted through the links to the harrow from an upward to a downward force. The linkage can adjust to this change and still retain its relief and motion capabilities. This allows carrier weight to be used for control of blade penetration. The entire weight of the carrier can be applied to the blades, or the carrier can be used to supply lift in the form of a high angle force line.

As the wheels are lowered and more of the carrier weight is taken off the blades, the carrier frame takes a higher position relative to the harrow frame, providing a useful indicator of the amount of carrier weight being applied.

When it is necessary to reduce the draft of the harrow, the A frame or carrier is raised. This changes the force line and brings about a change in draft with no direct lifting of the harrow. By this method draft corrections are made with a minimum of change in the working depth of the blade and a more consistent job is done.

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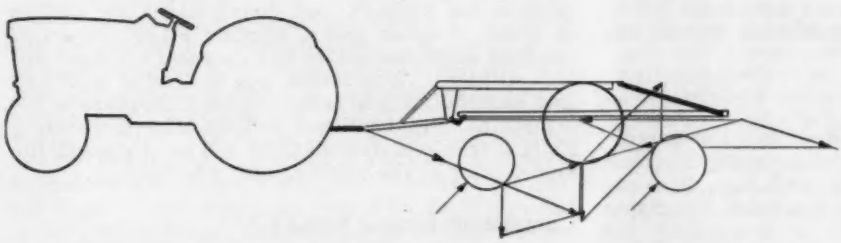

Fig. 3 — When carrier wheels are lifted off the ground, weight of carrier frame can be transferred to harrow frame through links as a vertical force in combination with tractor drawbar force.

Convair B-58 Supersonic Bomber undergoing cyclic fatigue test

Based on paper by

C. D. Little

Convair Division, General Dynamics Corp.

CONVAIR'S B-58 is being given an extremely comprehensive certification fatigue analysis, which will take two years to complete. Its purpose will be to:

1. Predict service life expectancy of the airframe for planned SAC usage.
2. Present results in terms of unit damage, so that service life expectancies for other airplane uses can be evaluated.
3. Present information to aid orderly maintenance planning and spare parts procurement.

This certification program, initiated at the request of the Air Force, has six major phases:

1. Development of load spectra — preliminary and refined.
2. Preparation of fatigue analyses — preliminary and final.
3. Development of test load spectra.
4. Fatigue test of components.
5. Fatigue test of complete airframe, airplane No. 29.
6. Flight data gathering programs:
   a. Dynamic response flight testing, airplane No. 5.
   b. Interim service loads, airplanes Nos. 12, 23.
   c. Service loads, airplanes Nos. 31 through 66.

Relationship of the major phases is shown in Fig. 1. In general, the program progresses from left to right to gain the objectives indicated by the two double-lined boxes.

Preliminary load spectrum

The fatigue load spectrum describes the magnitude-frequency history of the loads on the airplane and its components for a particular usage. Preliminary and refined spectra are programmed, the major distinction being the method of accounting for dynamic response effects.

The preliminary load spectrum is based on the B-58 flying a composite mission (which represents the average utilization of the airplane) derived from SAC predicted usage for a 10-year period. Required input data are shown at the left in Fig. 1. This preliminary load spectrum is the basis of the preliminary fatigue analysis and test load spectra for component testing and the start of complete airframe testing.

Preliminary fatigue analysis

The first objective is to evaluate fatigue damage resulting in the airframe due to the application of a fatigue load spectrum. Two fatigue analyses are planned — preliminary and final — based on preliminary and refined load spectra.

A series of fatigue tests is being conducted to establish criteria and data to be used in the preparation of fatigue analyses, as well as the development of test load spectra. *S-N* curves for two typical splices are being established — a wing panel splice and a fuselage longeron splice. Tensile coupon tests are also being conducted to determine other needed criteria, such as the effect of fatigue life of cylic stresses below the "knee" of the *S-N* curve.

Test load spectra

Here the objective is to develop a test load spectra for each component and for the airplane which are equivalent in terms of fatigue damage to the load spectrum but which are made up of higher loads and fewer cycles.

Since stress analyses of highly redundant structures under complex load distributions are subject to errors, Convair has a $\frac{3}{8}$-scale elastic model of the B-58 which simulates its structural arrangement and stiffness. This model can be loaded with any load distribution and is thoroughly instrumented for measuring the resultant strains and deflections. Fatigue test load distributions will be applied to the model prior to the start of airframe testing.

Component fatigue testing

Component fatigue testing was planned to obtain the earliest possible fatigue evaluation of those por-

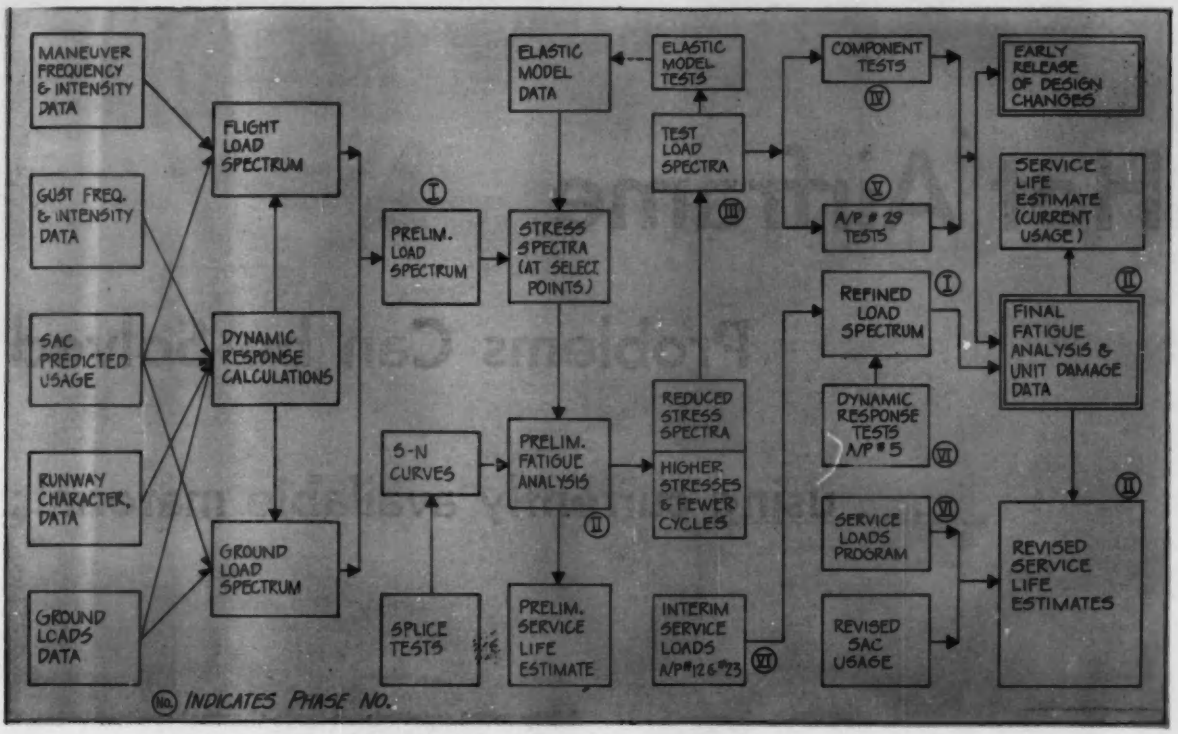

Fig. 1 — Relationship of the six major phases of Convair's cyclic fatigue test program for the B-58 supersonic bomber. Program reads from left to right to reach objectives indicated in the two double-lined boxes.

tions of the airframe whose failure in service would be catastrophic on present major retrofit problems.

A list of potential components and splices was compiled, then screened to leave only those which were to be subjected to relatively high repeated stresses in service. These components were then designed and released for manufacture so that they would be ready for testing when test load spectra would be available. Component testing includes four major components and seven splices and is scheduled to be essentially complete when the complete airframe testing begins.

Complete airframe testing

The cyclic fatigue testing will start early in 1960 and be completed eight months later. Cyclic loads will be applied by hydraulic rams. Approximately 34 channels of this equipment will control up to 61 rams for the most complex test load distribution. The test load spectrum will consist of about 200,000 cycles of load. The major part of the fatigue damage will be applied with ten layers of load, each layer consisting of five or six test load distributions typical of taxi, symmetric and unsymmetric flight, and landing conditions. The remaining damage will be accomplished by three test distributions to raise the fatigue damage in local areas to the required level.

Flight data gathering programs

Here the primary objective is to determine the elastic response characteristics under dynamic loading conditions. The data will be used to check and refine the calculated dynamic response effects in the fatigue load spectrum. The dynamic response flight testing by Convair calls for about 20 hours of flight for data gathering.

Interim service load and service load recording programs will be conducted by the Air Force.

Refined load spectrum

The preliminary load spectrum will be refined, using data from the dynamic response flight testing, interim service load program, and other available data. The refining will continue until all data from the foregoing flight programs are incorporated. If there are appreciable differences between the refined and preliminary load spectra, the refining will be extended to the preliminary fatigue analysis and to the test load spectrum for the complete airframe test.

The final fatigue analysis will be based on the refined fatigue load spectrum and will incorporate the results of all structural fatigue testing.

To Order Paper No. 108U . . .
. . . on which this article is based, turn to page 6.

Hot Airframe

Problems Can be Solved

. . . using currently available materials

Based on paper by

M. B. Dunn, M. D. Musgrove, and O. T. Ritchie
Boeing Airplane Co.

HOT-AIRFRAME design problems can be solved using currently available materials, properly selected and arranged. Exploiting radiant cooling and the advantageous thermal characteristics of materials in design, this article discusses built-up flat plate structures, cylindrical and conical shells, and thermally nonredundant configurations.

Flat plate type structures

Many structural arrangements used in wing design are of a flat-plate nature. Fig. 1 shows a number of designs that have been considered for low-thickness-ratio lifting surfaces. All of these designs are susceptible to thermal stresses. They can only be used where material and arrangement permit a high ultimate stress relative to the thermal stress. This means that a very high allowable stress capability must exist where large thermal gradients exist, or that thermal gradients must be low.

These panels should resist flutter and fatigue due to noise since they are inherently stiff. Panel dimensions as limited by internal support, however, must be considered in conjunction with panel bending stiffness. One thermal gradient source difficult to eliminate is that associated with transition. Fig. 2 shows the temperature variation in the transition region to be quite severe. Since transition is statistical in nature, it can be seen in Fig. 3 that the location of the thermal gradient is hard to fix and that the thermal stresses induced by transition may occur over a considerable portion of the structure. Note, too, that the uncertainty of the transition location is reduced at the higher Mach numbers.

Positive assurance of turbulent flow may be obtained by tripping the flow at or near the leading edge, thus eliminating the thermal gradient due to transition. This results in a higher average temperature for the structure. On the other hand, the impingement of shocks on the surface may result in a high rate of local heating due to the locally in-

THE THREE AUTHORS of this forward-looking solution to current hot-frame design problems total more than 50 yr experience in aircraft stress and structural analysis. **M. B. Dunn,** who was stress unit chief of the Minuteman project until last July, has been associated with both preliminary design stress and project stress work for many years. **M. D. Musgrove's** work has included strength and stability analysis of structural components in the presence of thermally induced plastic strains . . . and **O. T. Ritchie,** with Boeing since 1938, has supervised the strength checking and stress analysis for major components of many large bomber and transport airplanes.

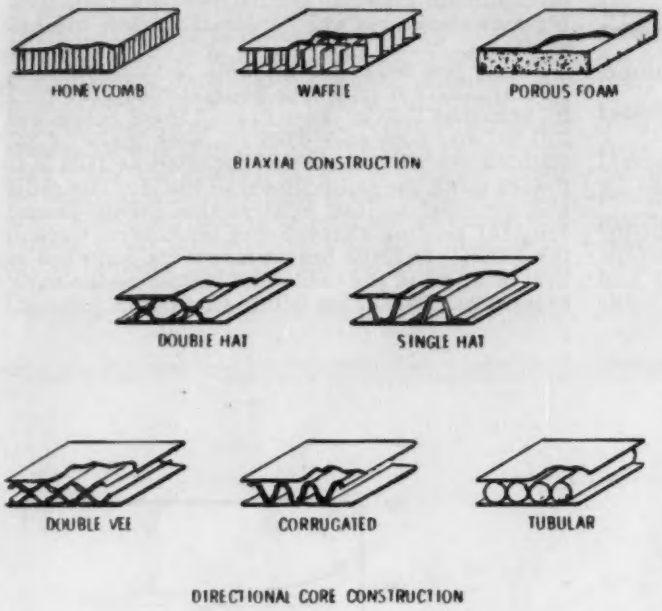

Fig. 1 — Typical sandwich surface constructions.

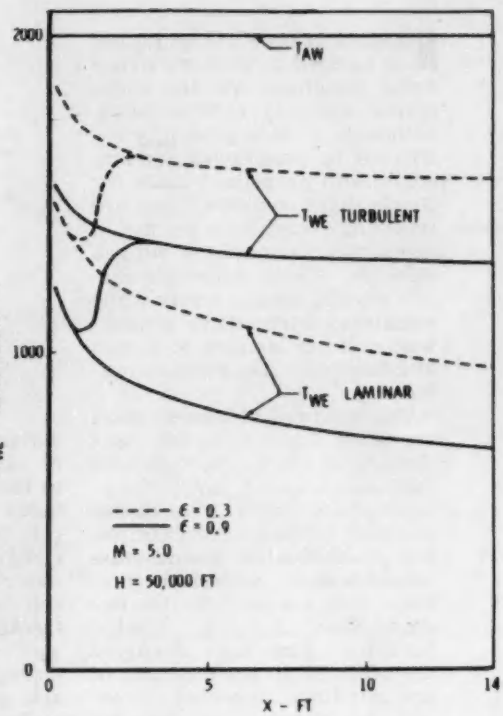

Fig. 2 — Effect of emissivity and transition on equilibrium wall temperature.

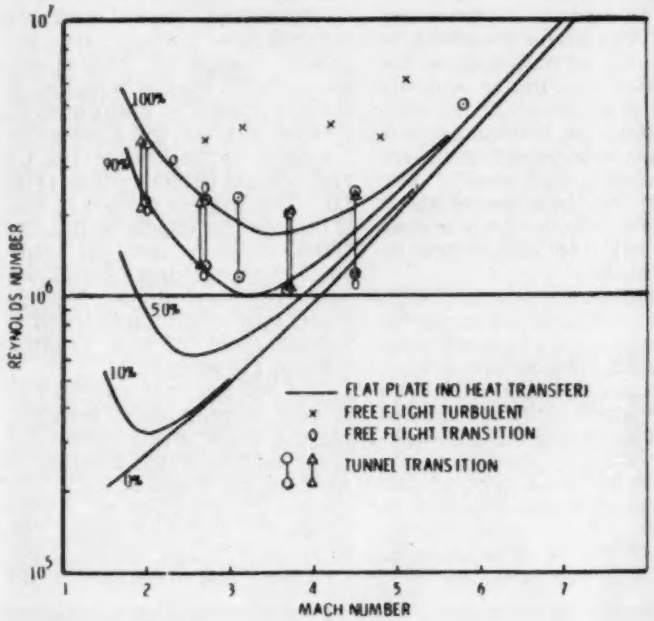

Fig. 3 — Probability for turbulent flow.

Hot Airframe Problems Can be Solved

... continued

creased pressure. If this occurs, severe thermal gradients and, hence, stresses are to be expected for any flow type.

Thus, flat-plate type structures have a "built-in" problem of thermal stresses. Designs, therefore, must be selected for high-strength capability and low weight. Honeycomb sandwich panels provide the optimum material arrangement for high temperature structures when thermal stresses are unavoidable.

Boeing has tested for ultimate bending strength several panels of solid-type honeycomb 2 ft × 3 ft × 2 in. brazed at 1900 F. Face gage of these panels was 0.01 in. and core gage 0.002 in., both made of 347 stainless steel. Tests were conducted at 1500 F to failure using the setup shown in Fig. 4. The setup was arranged so load and reaction points yielded constant bending moment over the central third of the panel. Radiant heat lamps were arranged to heat as much of the unblocked surface of the panel as possible. Calculated failure stress from four tests

New materials

NONMETALLICS are beginning to be used as primary structural materials for the more severe thermal environments. Although, to date, primarily restricted to nose cones, leading edges, and propellent cases for single flight vehicles, they are receiving recognition for use in the smaller unmanned winged vehicles. These materials satisfy several design needs while remaining competitive weightwise and are simpler to design and fabricate than metallic materials.

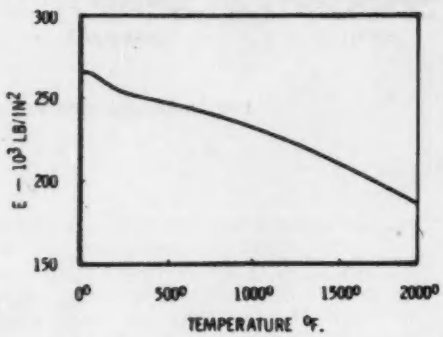

Fig. A — Young's modulus versus temperature.

The **lightweight nonmetallics** are good insulators, fair heat sinks, and, due to the thickness that can be used, not particularly susceptible to local flutter or noise damage. For example, the **resin-bonded wound-glass monofilament materials** have been used successfully for engine cases carrying internal pressure. Very high strengths are available in the direction of the windings, however, interlaminar shear strengths are usually quite low and the modulus of elasticity can be unfavorable for use in multistaged rockets where dynamic response of the entire vehicle is significant.

Materials consisting of **fiber and ceramic binder composites** offer interesting possibilities. **Fibrefrax,** which consists of aluminum silicate fibers bonded with a colloidal silica binder, is typical. This material may be formed with a wide variation of densities or even a density graduation within the component to fit various needs. It rates well in the thermal stress efficiency index. The major drawback to this family of materials is low elongation to rupture and the nature of rupture. Stress concentrations at fasteners cause fractures even though the average stress is small. The strength of these materials is also quite low, but they appear to be relatively unaffected by temperature.

Anticipating that attachment techniques will be developed for these materials, which act more as masonry than metals, a typical vehicle design has been evolved which could be expected to take advantage of the material.

Fig. A shows a plot of the modulus of elasticity used to evaluate the configuration shown in Fig. B. The material strength is approximately 1500 psi and the coefficient of thermal expansion is 2.5×10^{-6}. The configuration shown and its temperature pattern are assumed typical of high-speed, single-flight winged vehicles. A static analysis is performed at section A-A for the stresses in the plane of the section (Fig. C) and normal to the section (Fig. D). The stresses plotted in Fig. C include the effects of lift, internal pressure, and the transient temperatures associated with re-entry flight. Fig. D shows only longitudinal thermal stresses since the body bending stresses are quite small.

The stresses indicated in Fig. D were determined by computing the linear strain across the plane section which resulted in net internal loads equal to the externally applied loads. At the crown the plotted stresses, due to symmetry, are the principal stresses. The maximum is 495

is compared with compression yield strength in Table 1. Test four is interesting because this specimen had dimples formed by thermal stresses from applying high local heating while restraining the panel against deflection. Intercell dimpling from thermal stresses can be controlled somewhat by adjusting the core spread to give the faces greater support where the thermal gradients are anticipated, for example, where the wing passes through a fuselage. One disadvantage of solid brazed honeycomb surface is the limitation of size, since brazing facilities for large structures are not commonly available.

Another source of thermal stress in the flat-plate-type structure is the thermal gradient between the surface material and the spar material. Several arrangements of spar material are shown in Fig. 5. Spar A has a solid shear resistant web and is the type which will develop the greatest thermal stresses in the structure. Spars b and c relieve thermal stresses somewhat since thermal elongations within the spar can occur with relatively little restraint. Secondary stresses will exist since there are relative displacements in the surface material or within the spar material itself, but these are usually of little consequence.

The solid web is not necessarily the least efficient of spar arrangements. The other designs shown will

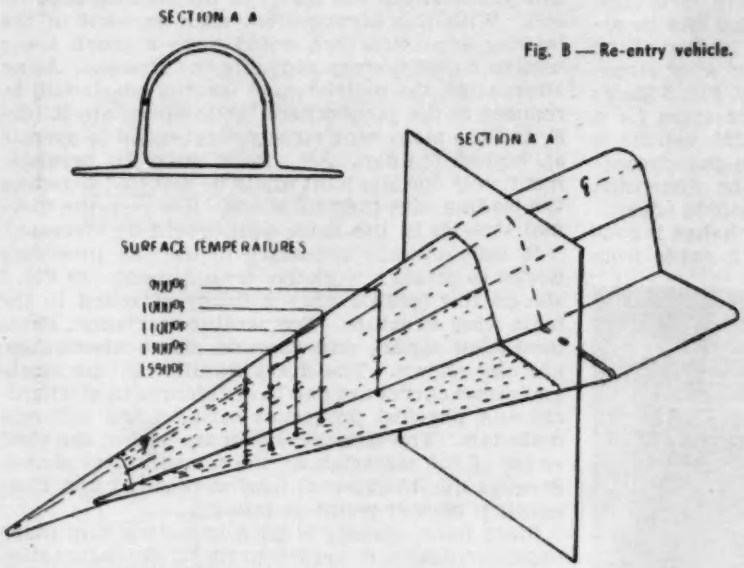

Fig. B — Re-entry vehicle.

psi in compression. The maximum principal stress in the outer face of the vertical side just above the wing is approximately 1430 psi in compression and is the maximum stress in the structure. The junctures of the wall to the wing are filleted to prevent failure due to triaxial stresses.

While analysis indicates that **aluminum silicates** are feasible structural materials, there are many problems such as surface hardness for erosion and resistance to damage in handling and servicing. Although these materials are simply and cheaply fabricated, this virtue is not so strong when the problem of attachments is considered. However, with development these problems should be overcome.

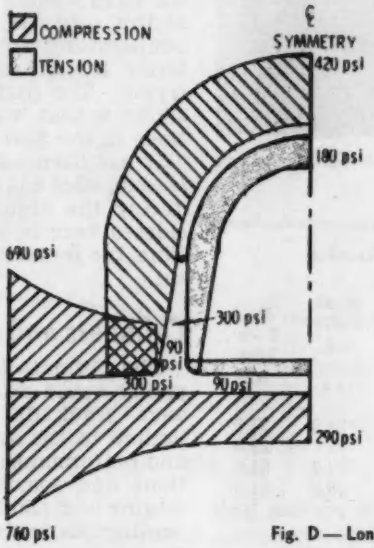

Fig. D — Longitudinal thermal stresses.

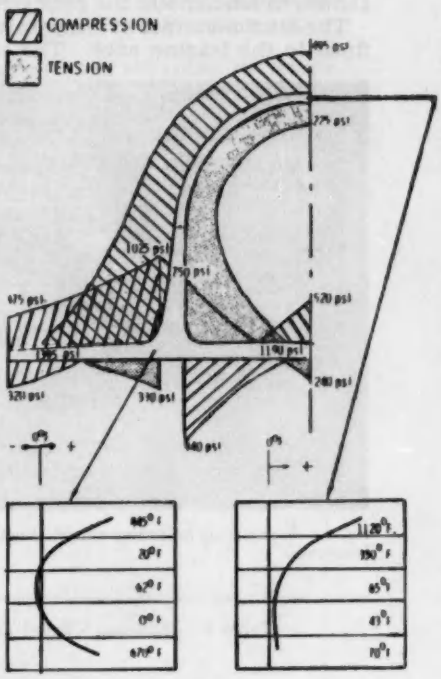

Fig. C — Transverse stresses; thermal, airload, and internal pressure.

have fitting and joining problems, and lower shear strength capability in some cases, which may reduce their strength-weight value. The need for shearing rigidity, however, may make it desirable to use the solid web even though the thermal stresses are quite large. The cover material doesn't help much in resisting the higher bending mode flutter unless shear rigidity is provided between the surfaces. Thermally nonredundant spars are relatively inefficient in providing shear rigidity and therefore may be undesirable. Post stiffening offers support to surface material, but does not aid in carrying shear.

Marked variation of the heat transfer coefficient in the vicinity of the leading edge presents a severe gradient source on a lifting surface. Fig. 2 shows this to be so for both laminated and turbulent flow. Sometimes the configuration is such that large thermal loads may be avoided; for example, if segmented leading edge flaps, which do not have structural continuity, are employed. Also, stresses can be altered somewhat by permitting relative motion of the leading edge with respect to the main wing structure. As an example of this possibility, Fig. 6 shows a cross section of the leading edge structure for a hypersonic vehicle. The sweep on this vehicle is quite extreme and the leading edge in the streamwise direction is about four times the dimension shown, which denotes the geometric leading edge.

The maximum rate of temperature change is confined to the leading edge. The edge is made from molybdenum 0.5% titanium alloy while the main wing structure is solid honeycomb in M-252, a nickel base super alloy. The shape of the leading edge is maintained by thin bulkheads which are parallel to the plane of the sketch. The purpose of the slipping joint is to let the leading edge expand independently of the main wing, which it will do except for frictional forces. Thus, a considerable reduction in wing thermal load would be expected. But thermal stresses in the leading edge aren't eliminated. In fact, for the thermal gradient shown, the induced curvature of the section would be quite large and the bending moment required to hold the leading edge flat against the main wing would also be large.

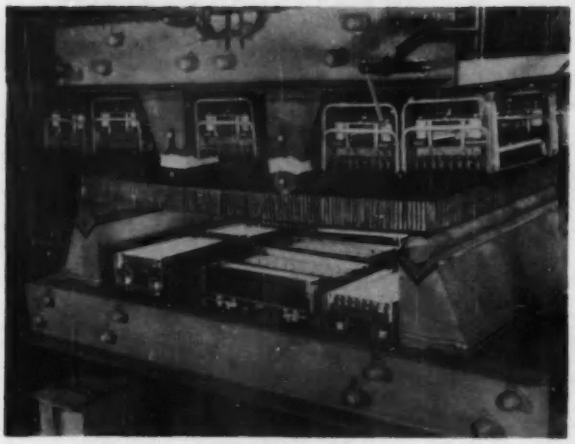

Fig. 4 — Boeing setup for testing ultimate bending strength of solid-type honeycomb.

Table 1 — Sandwich Panel Test Results

Panel	Width, in.	1/3 Point Load at Failure	Moment, in. lb	End Load in Skin, lb	fc at Failure, kips/in.²	$F_{cr}/1-\nu^2$, kips/in.²
1	23	1070	11,700	5850	**25.5	21.5
2	23.56	1175	12,800	6400	27	21.5
3	23.62	1180	12,900	6450	27.2	21.5
*4	18.31	630	6,880	3440	18.8	21.5

* Panel with initial intercell buckles from previous high heat application.
** Failure occurred at load point instead of midspan.

The stresses due to the restraint against curving would be added to those resulting from the nonlinear character of the temperature variation. One way to minimize these stresses would be to add similar slip joints within the limits of the leading edge itself. With this arrangement each segment of the leading edge structure would have a much lower section depth thereby reducing the stresses. As an alternative, the molybdenum leading edge could be reduced to the point where the temperature is 1690 F, and the main wing structure extended to operate at higher temperatures. With such an arrangement, only one slip joint would be required to reduce the leading edge thermal stress. However, the thermal stresses in the main wing would be increased.

It isn't actually necessary to use the preceding device to obtain a workable arrangement. In Fig. 7 the narrow leading edge is firmly attached to the main wing structure. Temperature variation, stress producing strain, and thermal stress distribution are also shown. The discontinuities in the strain and stress curves are due to differences in mechanical and physical properties between the different materials. The stresses shown are within the yield stress of the materials at the temperatures shown. Stresses due to external load were small and their addition doesn't result in failure.

Since joint slippage is hard to control and much experimentation is needed to fix its characteristics, the fixed leading edge seems to be the best solution in this case. If, however, the leading edge region temperatures are too severe for the basic wing material, the slipping joint scheme should be worth trying. The particular advantage of the slip joint shown is that it shouldn't cause significant disruptions in the flow and trip the boundary layer.

It has been assumed here that the molybdenum leading edge has a coating which prevents oxidation during the flight period. Since the vehicle considered here is a one shot job with modest flight time, the protection of molybdenum appears practical.

Cylinders and shells

The ultimate in rocket design and analysis simplicity would exist if only one continuous cylinder were required, having environmental variations limited to the axial direction. However, efficiency and performance requirements demand conical sections and sometimes control surfaces to provide staging and stability. These features result in discontinuities in the structure as well as variations in the local environment. When the variations in the temperature occur only in the axial direction and

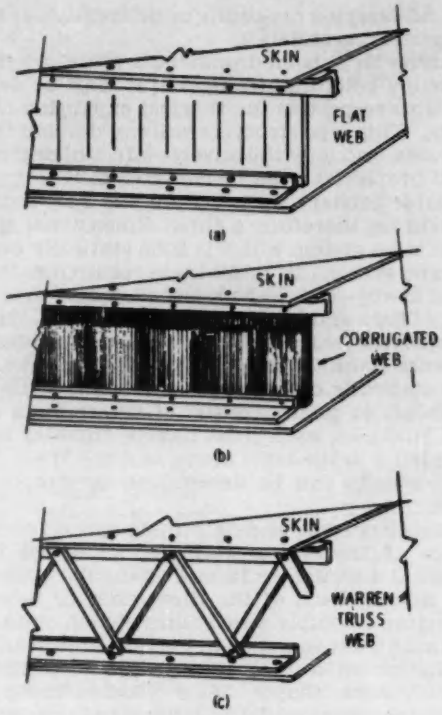

Fig. 5 — Wing spar constructions.

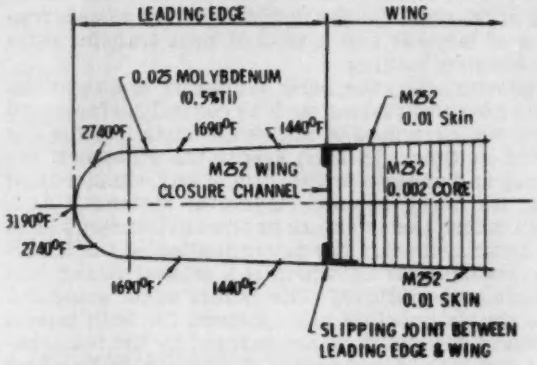

Fig. 6 — Wing leading edge section with leading edge temperature distribution as shown.

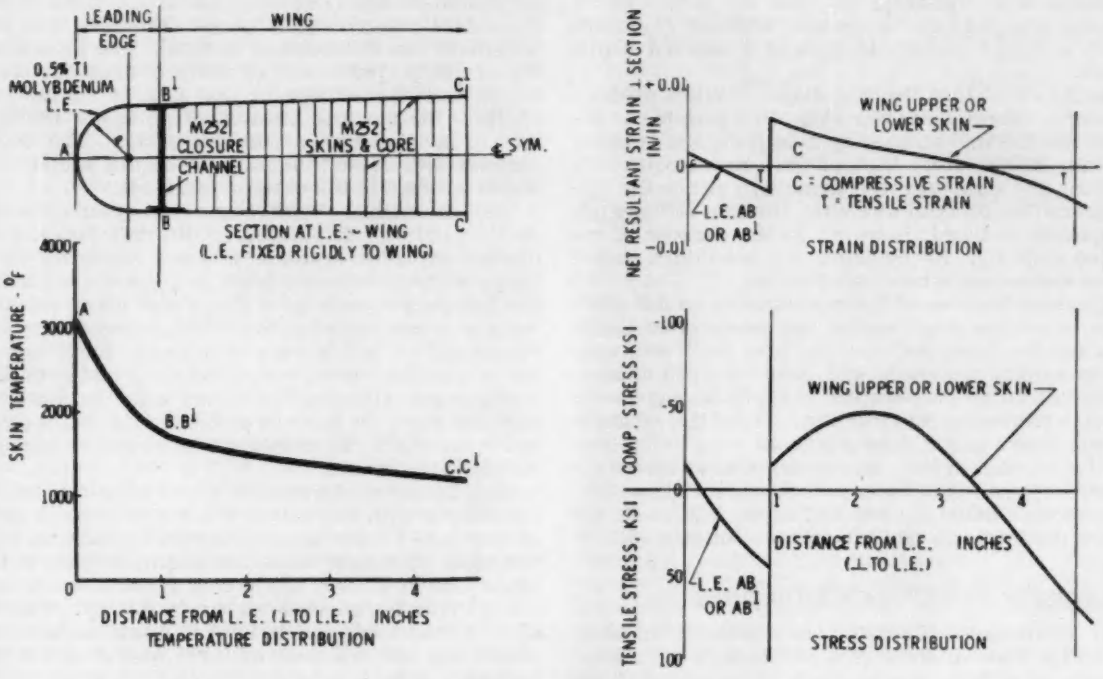
LEADING EDGE
WING
0.5% TI MOLYBDENUM L.E.
M252 CLOSURE CHANNEL
M252 SKINS & CORE
℄ SYM.
SECTION AT L.E. ~ WING (L.E. FIXED RIGIDLY TO WING)
SKIN TEMPERATURE - °F
DISTANCE FROM L. E. (⊥ TO L.E.) INCHES
TEMPERATURE DISTRIBUTION
NET RESULTANT STRAIN ⊥ SECTION IN/IN
WING UPPER OR LOWER SKIN
C = COMPRESSIVE STRAIN
T = TENSILE STRAIN
L.E. AB OR AB'
STRAIN DISTRIBUTION
COMP. STRESS KSI
TENSILE STRESS, KSI
WING UPPER OR LOWER SKIN
DISTANCE FROM L.E. INCHES (⊥ TO L.E.)
L.E. AB OR AB'
STRESS DISTRIBUTION

Fig. 7 — Rigidly attached molybdenum leading edge.

are relatively gradual, the resulting thermal stresses are small and can be neglected. Even when structural discontinuities result in more rapid temperature variations due to heat sink changes, the resulting stresses can be accounted for due to the polar symmetry of the system.

Cylindrical shell thermal stresses are due to deviations from the linear in the axial temperature gratient rather than due to the gradient itself, for a constant gradient in a cylinder simply results in an unstressed conical section. The temperature variations associated with the transition from the conical to cylindrical sections are frequently quite large due to the local angle of attack change and the variation in character of the flow which may possess features of laminar and turbulent heat transfer rates in a complex manner.

Unfortunately, the polar symmetry is lost in the areas near protrusions such as control surfaces and when vehicle angles of attack are sustained for any period of time. In such events the structural response and analysis is but little, if any, simpler than with the more general structural systems. Also, when either the structure or the environment loses the polar symmetry the determination of the allowable buckling stress, which is a critical factor, can become quite difficult. The failure mode would not be a simple buckling phenomenon, for both lateral load and deformations are induced by the temperature and lack of symmetry. Therefore, in this case as in many others, the classical buckling stresses are not applicable as allowable stresses. Actually the classical buckling stresses should be considered simply as a maximum value which only in specific cases can be used as allowable stresses.

Conical sections are quite similar to cylindrical elements with the exception that the radius varies axially, and that the shear and bending responses carry a direct analogy to that of a tapered depth beam.

In the event that thermal discontinuities produce excessive thermal stresses, it is often possible to reduce the thermal stresses by modifying the cylinder or cone design from that of pure monocoque. By making the structure wall flexible in either the circumferential or axial direction, thermal stresses are frequently reduced; however, at the expense of reduced stability. Recognizing this possibility should allow a reasonable balance of design.

The bad features of thermal stresses in flat plate type structures are likewise bad features in shells. Designs for fuselages, nacelles, and such, will generally employ materials with good strength characteristics at high temperature in stable arrangements such as sandwich construction. Thus, the arrangements shown in Fig. 1 for wings will also be applicable for fuselage shells. At extreme temperatures the thermally nonredundant space frame should be useful, though panel flutter and sonic fatigue of the cover material are likely to present difficulties.

Thermally determinate structures

In severe cases of aerodynamic heating, the thermal expansion of structural elements is large when compared with the elastic strain of the material, and high thermal stresses are produced in conventional structures which may equal or exceed the drastically reduced strength of the material. This results in loss of load carrying capability or destruction of considerable structural detail.

To survive in this environment a structure must be thermally determinate; that is, it must be determinate with respect to the thermal expansion of its elements. This type structure will not develop thermal stresses, and only the adverse effect of degraded material properties need be considered.

A suitable primary structure for the very hot vehicle could be, therefore, a three dimensional space frame or truss system which is both statically determinate and stable. To fulfill these requirements the equation $m = 3j - 6$ must be satisfied, where m is the number of bars and j is the number of joints. However, satisfying this condition does not automatically assure stability. Generally, a space frame will be both statically determinate and stable if its external facets or planes consist of determinate systems of triangles, each joint having three or more bars not lying in the same plane, and $m = 3j - 6$. Instability usually can be determined by simple inspection.

The simplest form of determinate space frame is a system of transverse triangles connected in a longitudinal direction to form a triangular prism or similar shape. Each of the three sides or faces of the structure is simply a two dimensional, statically determinate truss as shown in Fig. 8a. However, the triangular prism is neither an efficient container nor aerodynamic shape. More complex truss systems can be developed similarly using transverse polygons of four or more sides in place of the triangle (Figs. 8b and 8c).

Sufficient requirements can be stated for static determinancy of three dimensional trusses. Each of the sides of the frame must project as a two dimensional statically determinate truss. Two of the transverse polygons must project as stable and determinate two dimensional systems. The remaining transverse polygons will be without diagonals and, hence, unstable except in the case of simple triangles. Neither the transverse polygons nor the sides of the frame are necessarily planar. Also, more complex systems can be built up by the addition of tripod systems to the external surfaces.

Two advantages of the simple triangular truss are worth mention. Expansion of internal bars simply rotates adjacent sections without changing their shape while in a higher order polygon system all of the polygons change their shape and plane sections become three dimensional. Thus, distortions are minimized in the triangular system. Each bay of the triangular system is stable as it is added during construction, whereas the higher order systems are unstable until the last bar of the second stable polygon is installed. Therefore, the triangular system is simpler to fabricate.

This advantage of simpler fabrication can be incorporated with the larger volume-to-surface ratio of the higher order polygon system by starting with the basic triangular truss and adding tripods to the sides such that only three bars meet at each new joint. This technique is shown in Fig. 8d. Successive addition of tripod systems in a lateral direction allows the development of large and complex but statically determinate structures.

For thermal stress elimination to be realized, the joints of the space frame should be of a universal type. Since such joints are heavy all thermal

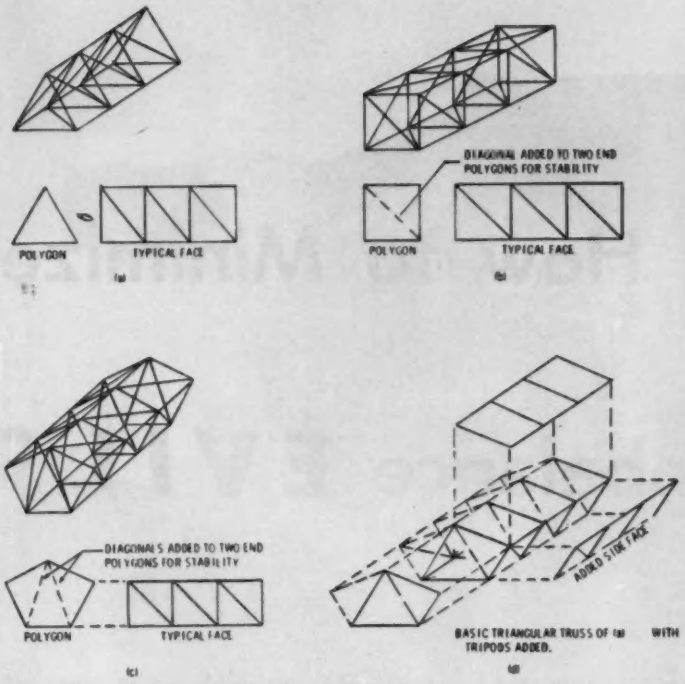

Fig. 8 — Thermally nonredundant space frames.

stresses won't be eliminated. Those that remain, however, will be secondary and can be kept small by noting where the truss member angle changes are greatest and putting the rotational capability at those places.

The conventional vehicle of today employs a highly redundant structure in which bending and torsional shear stresses are carried mainly by the cover material. This type cover, however, isn't suitable for the thermally determinate structure. The surface of this type vehicle must not interfere with the determinate nature of the primary substructure if thermal stresses are to be eliminated. This requirement can be met by using a system of cover panels which carry local air loads only, using flexible supports at the panel edges to avoid lateral restraint and to carry the panel load into the substructure without introducing redundancy. This method is shown in Fig. 9 using corrugated cover panels supported by short Z-sections attached to the primary structure. Angles or channels could also be used but, whatever type, they should be short sections rather than long continuous sections.

Spacing of the supports at the panel edge will be influenced by the local air load and the type of cover material. For the panel in Fig. 9, supports along an edge parallel to the direction of the corrugations serve principally to maintain contact between adjacent panels and spacing may be relatively large. Supports along an edge running across the corrugations carry most of the panel load; consequently, they should be more closely spaced. The direction of the corrugations should be normal to the direction of the isotherms to reduce the thermal stresses that build up within the individual suspended panels. The outer skin must be thin to buckle at low stress levels due to the variations in thermal expansion across the panels.

Due to the flexibility of the panel supports, panel flutter and sonic fatigue present problems and careful analysis is needed for their elimination. Panel

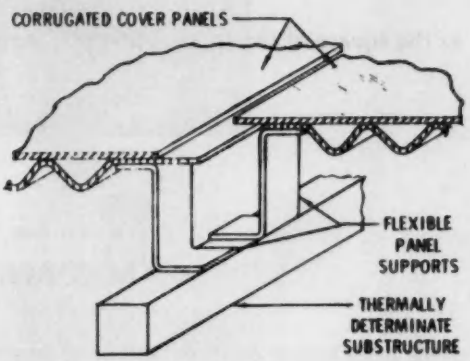

Fig. 9 — Cover panel for thermally nonredundant space frames.

joints must be free to slip laterally to allow individual panel expansion without restraint from adjacent panels; otherwise, severe thermal stresses and panel buckling may occur. This implies some sort of butt joint between the outer skins of adjacent panels with sufficient clearance between the butted edges to allow for a relatively large thermal expansion. This may result in aerodynamic smoothness problems but should, in any case, be investigated.

For a hypersonic vehicle configuration, a comparison has been made between a solid honeycomb construction of super alloy and the thermally determinate construction mentioned. The results showed that the structural weights were nearly the same with some advantage to the thermally determinate structure at skin temperatures around 1500 F. At higher temperatures, the advantage would be increased.

To Order Paper No. 104U . . .
. . . on which this article is based, turn to page 6.

How to Minimize

Engine Unbalance EVILS

Higher rotational speeds affect forces produced by unbalance

as the square of the rpm . . . bringing major problems, as engine and road speeds keep going up.

Based on paper by

M. G. Avery

Reo Division, White Motor Co.

AN ENGINE ASSEMBLY can't be balanced by any so-called "one-shot deal." Careful weighing and balancing of component parts must be accomplished . . . by the manufacturer before the engine leaves the factory; by maintenance personnel from time to time in the field. And the tools are available by which unbalance can be reduced from a major problem to just an annoyance. But both manufacturer and service man must do an adequate balancing job if the increasing problems brought by higher engine and road speeds are to be minimized. The forces produced by unbalanced parts can:

- Cause loads and vibrations which add to the power requirements of a system.
- Produce motions or vibrations which may contribute to fatigue failure of various parts.
- Produce cracking and breaking of generator brackets, coil mounts, air cleaner parts, and other bracket-mounted accessories.
- Cause a rough "feeling" to which drivers object.
- Cause movement of mirrors or hood ornaments to produce fatigue.

Control by manufacturer

The case of a 6-cyl engine designed to operate at a governed speed of 3400 rpm — and of an 8-cyl engine of the same bore and stroke — will illustrate how the manufacturer and the maintenance man can exercise controls to limit unbalance.

In the case of the 6-cyl engine, the following limits would be typical:

1. Piston: 1 lb 14 5/16 oz $\pm$ 1/8 oz
2. Connecting rod: top end 13.76 oz $\pm$ 1/16 oz; bottom end 2 lb 5.12 oz $\pm$ 1/16 oz
3. Crankshaft: dynamically balanced — both ends within 1/4 oz-in.
4. Flywheel: dynamically balanced within 1/4 oz-in.
5. Piston pins, piston rings, and bearing shells are machined all over to close tolerances and of homogenous materials so that only occasional weight checks are made
6. Pulleys: dynamically balanced within 1/4 oz-in.

In the case of a V-8 engine, the limits would be established the same as for the 6-cyl engine, although the actual weight of piston and rod would be different due to engine configuration.

The difference in the balancing procedure or technique is in the crankshaft. A normal 6-cyl crankshaft is inherently a balanced structure except for forging or casting variations in the surfaces not machined . . . and these are balanced out in the bal-

Fig. 1 — Engine on stand ready for balance check by an electronic engine balancer at Reo.

ancing procedure. The V-8 crankshaft itself is inherently an unbalanced structure. The balance inherent in the 6-cyl crankshaft is due to the equal spacing of the crank throws, two sets of crank throws being spaced at 120 deg intervals. The horizontal and vertical components of the forces produced by the reciprocating parts of the 6-cyl engine also nullify each other if properly weighed.

In the V-8 crankshaft, the crank throws are in two planes 90 deg apart and the forces due to the reciprocating parts also act in these two planes. So, counterweighting must be properly designed to compensate for these forces, which do not nullify each other. The V-8 crankshaft, therefore, must be balanced with "bob weights" attached to the crank pins. These "bob weights" must be of an accurate weight and must simulate the effective weight of the connecting rod and piston assemblies. These weights are calculated taking into consideration the weight of the piston, piston pin, piston pin locks, piston rings, connecting rod assembly, and bearing shells.

Recently, some manufacturers of high-speed V-8 engines have been utilizing new equipment, which was designed to balance complete engine assemblies. This operation is in addition to the aforementioned controls and insures a completely balanced unit. Such a unit is an electronic engine balancer (manufactured by International Research & Development

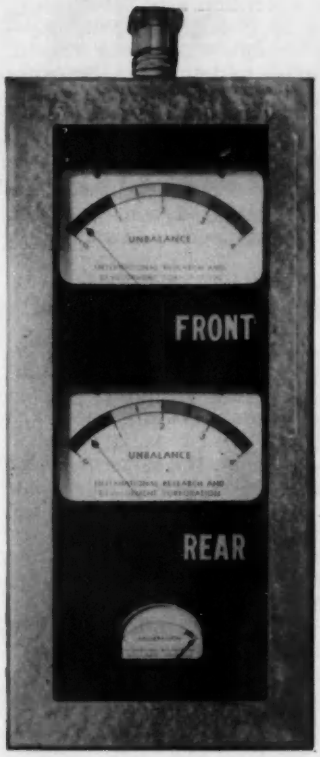

Fig. 2 — Dials on electronic engine balancer showing the amount of unbalance in the engine being balanced.

How to Minimize Engine Unbalance Evils

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Corp.) which will determine the amount and direction of unbalance in the engine when running. Then, the unbalance, if any, can be corrected by drilling the flywheel or front crankshaft pulley.

At Reo, we do not balance with the clutch assembled because we are not always sure which type of clutch will be applied to the vehicle. Clutches are quite often changed in the field and this, too, presents a problem. Desirable as it might seem to be to balance with the clutch, it is not practical for us to do so and, fortunately, the application of a properly balanced clutch does not materially change the overall assembly balance.

An engine on the stand ready for balance check is shown in Fig. 1 and the dials indicating the amount of unbalance in Fig. 2.

A valuable function of this unit is for quality control. It readily determines if a production operation, for part balance, is getting out of control. Most engines do not need balancing after assembly if all individual weighing and balancing operations are kept within limits. Tentative limits established for this assembly balancing operation are: satisfactory without balance drilling up to 3 oz-in.; balance by drilling up to 4½ oz-in. to come within the 3 oz-in. limit; reject and disassemble to determine the cause of unbalance over 4½ oz-in.

Since the inception of this program, production limits have been well adhered to; all engines except for rare exceptions have met our rigid requirements.

Engineering did not escape completely unscathed from surveillance of this gimlet-eyed monster either, as we had to do a little re-engineering to attain our present standards.

Control in the field

In the maintenance shop, parts going into a rebuilt engine assembly should be weighed and balanced just as they are in a new assembly.

Here, the 6-cyl engine presents fewer problems in respect to balance than the V-8. It is sufficient in the six that the pistons all weigh the same and that the top and bottom ends of the rods weigh the same as others in the set. A specific weight figure is not necessary . . . and it usually is easiest to find the lightest piece in the set and remove material from the weight lugs of the heavier pieces until all weigh the same. A small balance scale of reasonable accuracy can be used for this purpose and the weight limits as used by the manufacturer can be closely approached if not met.

The crankshaft, if reground, should be checked for balance. For this operation, a balancing machine is necessary.

In most of the larger cities, there are machine shops or "hot rod" shops that will do this work. One added caution at this point: the pilot on the crankshaft for the flywheel and the pilot bore in the flywheel should be checked to see that they are clean and free of burrs. The pilot on the crank should be checked for run-out with respect to the main bearings. A crankshaft and flywheel individually balanced but assembled with excessive run-out will produce an unbalanced assembly. A 60-lb flywheel rotating 0.002 in. off center produces an unbalance of nearly 2 oz-in.

The flywheel should be dynamically balanced, especially if it has been refaced.

Pulleys can be satisfactorily balanced statically on an arbor and rolls by exercising a little care.

In the V-8 engines, all the foregoing limits would apply except that the piston assemblies and rod assemblies must be matched not only in sets for weight but must be of an exact specified weight. The V-8 crankshaft must also be balanced with "bob weights" attached. This fact often leads to difficulties if the owner wishes to rebuild the engine with other than original equipment supplied by the manufacturer. The replacement parts may not meet the original weight requirements and thereby introduce rather serious difficulties with vibration. This problem can be resolved by calculating and making new "bob weights" and rebalancing the crankshaft with these new weights attached. But this is generally not considered a practical field procedure except in the very best equipped shops. Usually, it is easier and more satisfactory to use original equipment parts.

Balancing a complete assembly is a different matter since, at the present time, there are available portable vibration analyzers which will do in the field the same job the engine assembly balancer does for the manufacturer. They can be used to check engine assemblies while running or being motored. The more universal types can, in fact, be used to balance practically any rotating piece of machinery. The large fleet operator who has vibration problems could well afford to use this type equipment as its application is usually limited only by the ingenuity of the people using it.

As with most equipment, this type has some limitations when used for balancing assemblies in the field. For instance:

- The very nature of the balancing operation — which involves addition or removal of weights from one of the rotating members — may preclude using this member on another assembly with satisfactory results. . . . This may limit exchange of parts from one engine to another unless the assembly is rebalanced.

- A satisfactory spot must be found at which to remove or add the weight necessary to bring the assembly into balance. Such a spot is where drilling may be accomplished or weights added without adversely affecting the strength or functioning of the part. (Careful attention to weighing and balancing individual parts will minimize this problem.)

Longer life, minimum maintenance, and reduced costs are the rewards to be expected from proper application of today's balancing tools.

To Order Paper No. 114U . . .
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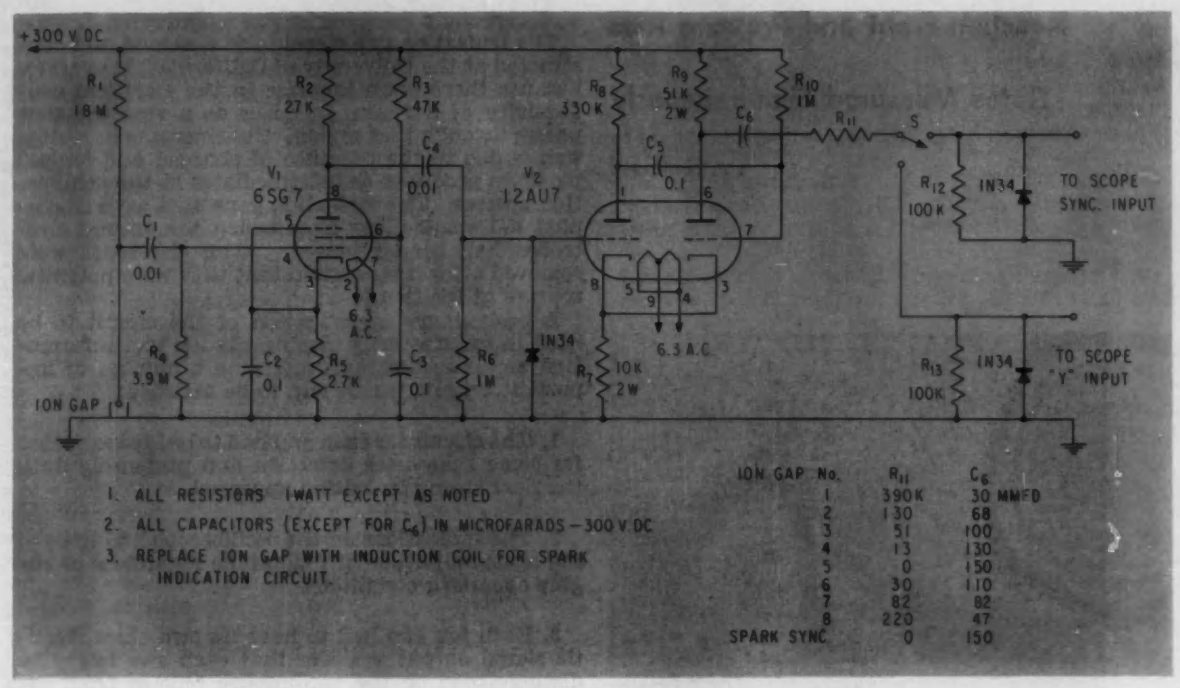

Fig. 1 — Reaction front detection circuit.

Reaction Front and Pressure Rise Rates Measured Simultaneously in spark-ignition engines

Excerpts from paper by

E. S. Starkman and F. M. Strange
University of California

and T. J. Dahm, General Electric Co.

EQUIPMENT has been developed which simultaneously displays (on one oscilloscope screen) the pressure-time and reaction front-time histories in a spark-ignition engine.

Experiments with this instrumentation showed that:

- In most cases the peak pressure was developed many crank angle degrees after the initial reaction front had completely traversed the combustion space.
- Cycle-to-cycle variation of pressure development is caused by variations in the time lag between ignition and the establishment of a regular reaction front. Reaction front propagation rates were fairly constant.
- Reaction front rates depend on fuel-air ratio as well as fuel type. Rates for highly preignition-prone fuels (the nitroparaffins) were unexpectedly of the same order as for isooctane. Methanol rates were higher.

Instrumentation and procedure

The experiments were conducted with a modified CFR Supercharge Method engine. The valve-in-head cylinder was replaced with an L-head cylinder

Reaction Front and Pressure Rise Rates Measured Simultaneously

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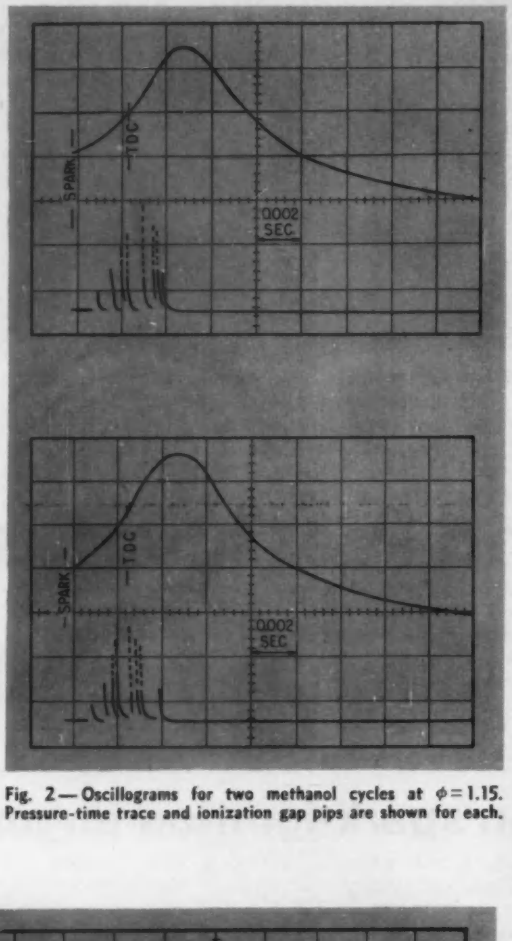

Fig. 2 — Oscillograms for two methanol cycles at $\phi = 1.15$. Pressure-time trace and ionization gap pips are shown for each.

Fig. 3 — Oscillogram for isooctane at $\phi = 1.15$.

and a specially designed bronze cylinder head.

The ionization gap circuit was designed and constructed at the University of California. It operates because there is an increase in the electrical conductivity of a region in space as a reaction zone passes through that region. This increase in ionization is due to the presence of charged and ionized particles produced as intermediates in the combustion process. The ionization gaps used were Champion V-1 spark plugs from which the ground electrodes had been removed. (The electrodes were removed after it was found that they were potential sources of ignition.)

A preliminary investigation of the circuit to be used in satisfactorily placing the ion gap information on an oscillograph indicated a number of important criteria which had to be satisfied:

1. The circuit for each gap had to be incapacitated for some time after detection and preferably until the next strong ionization appeared.

2. The indications on the oscilloscope had to be of the same amplitude or magnitude regardless of engine operating conditions.

3. Each ion gap had to have its own characteristic signal output in order that each gap might be distinguished on the oscilloscope records from the others.

4. Separate indications from each ion gap had to be displayed on the oscilloscope during intervals of time on the order of 50 microsec in order to obtain proper resolution.

The circuit finally evolved is shown in Fig. 1 for one ionization gap. Nine of these circuits, identical except for variations in the final resistance-capacitance network, were ganged together and connected to the oscilloscope. One of the nine was inductively connected to the spark secondary circuit and was used to trigger the oscilloscope sweep.

A Rutishauser Corp. capacitive-type pressure transducer was used for the pressure indication. The pressure pickup was mounted in the cylinder head in a position such that the diaphragm of the pickup was flush with the roof of the combustion chamber. This reduced the problem of false readings due to constrictive passages leading to the pressure pickup.

Simultaneously recording the reaction front progress and the pressure-time history of selected individual cycles was accomplished by the use of a dual channel oscilloscope and an oscilloscope camera. The output of the reaction front detection system was placed on one channel and the pressure transducer output was placed on the other. With the camera shutter open, the sweep circuit was pulsed by the ignition spark and the pressure-time and reaction front-time data recorded for a single cycle.

Experimental results

Two of the photographic records obtained in the experimental work are shown in Fig. 2. The fuel was methanol being run at an equivalence ratio of 1.15. (Equivalence ratio, ϕ, is defined as the actual

fuel-air ratio divided by the stoichiometric fuel-air ratio.) For each cycle the pressure-time trace and the ionization gap pips are shown. The ionization gaps are keyed in height for identification purposes. The cycle shown at the top of Fig. 2 most clearly indicates an orderly progress of the reaction front across the combustion chamber. The pips are keyed in an ascending-descending sequence.

Since the physical distance between ionization gaps was known beforehand, the reaction front velocity could be determined by a direct plot of the data.

Fig. 2 shows that the entire mixture had begun to react, as indicated by the firing of the last ionization gap, well before the peak pressure of the cycle was reached. For example, analysis of the top cycle showed that all of the ionization gaps had fired by 15 deg after top dead center while the peak pressure of the cycle was not reached until about 25 deg after top dead center. At this point the volume of the system was 32% greater that at top dead center. This increased volume must be taken into consideration when assessing the extent of reactions taking place after the last ionization gap has fired.

In some research on flame front propagation the premise has been made that the complete chemical reaction occurred in a very narrow zone called the flame front. It followed then that the time for completion of the chemical reaction had to be negligible compared to the time scale for other engine events. An examination of Fig. 2 leads to exactly the opposite conclusion — the reaction is not instantaneous and the time for completion can become considerable and important.

Peak pressure alone may not be sufficient to indicate completion of the combustion reactions and consideration must be made for the changing volume of the system. Had such been accounted for, the time between the indication of the last ion gap and the actual completion of combustion would have been even greater.

The implication of the above is most important to those involved in the investigation of the interrelationships between combustion and engine mechanisms and structures. As example, definite limits to the development of pressure in a reciprocating engine do exist and if these are exceeded, "rough" engine operation will result. The general tendency has been to design the combustion chamber to control the rate of pressure rise by controlling the rate of energy release. The calculation of energy release rate is usually made on the assumption that the energy is completely released at the so-called flame front.

As long as the specific output remains low and the relative mass of the engine parts is high, this assumption is a sufficiently good approximation. If, however, a light engine is to be operated successfully at very high power output, it is essential to know more precisely how and when the energy is released in the process of the combustion reactions.

The current model of a combustion reaction indicates that many steps are required to transform the reactants into combustion products. It must be recognized that some of the intermediate reactions may be endothermic while others are exothermic; that all reactions need not have the same propagation rates. Perhaps most important, the reaction equilibria shift with temperature and pressure, and it cannot be assumed that the same set of reactions hold throughout the combustion process.

Thus, it is possible to understand why records such as Fig. 2 are obtained. In this case it is interpreted that the major exothermic reaction followed the initial ionization reaction by an appreciable and measurable time.

The results shown in Fig. 3 are for isooctane, at an equivalence ratio of 1.15. There is the same time lag of peak pressure until well after the firing of the last ionization gap.

Not all records obtained showed as long time intervals as indicated above, however, and in some instances the times were very much shorter.

Comparison with calculated cycle

A calculation was made of the pressure-time history of a hypothetical cycle in which the reaction was assumed to go to completion instantaneously with the arrival of the reaction front. (The fuel was nitropropane.) A comparison of this with the pressure-time history of an actual cycle gives an indication of the degree of completion at any time.

Fig. 4 was constructed from data obtained from an oscillogram similar to Figs. 2 and 3. The dashed reaction front line has been drawn in to indicate how the average apparent reaction front rate was determined. This was interpreted as being 130 fps in this case.

Fig. 5 shows the calculated curve of equilibrium combustion pressure as a function of the volume fraction of the original charge ignited for a nitropropane-air system at the same fuel-air ratio as Fig.

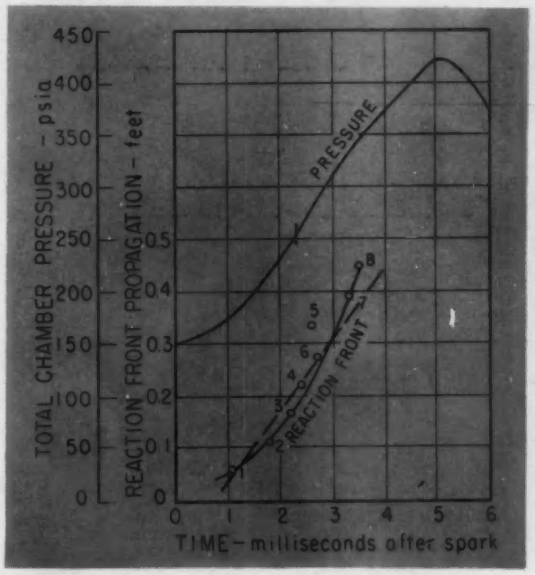

Fig. 4 — Pressure and reaction front histories for nitropropane at $\phi = 1.15$.

Reaction Front and Pressure Rise Rates Measured Simultaneously

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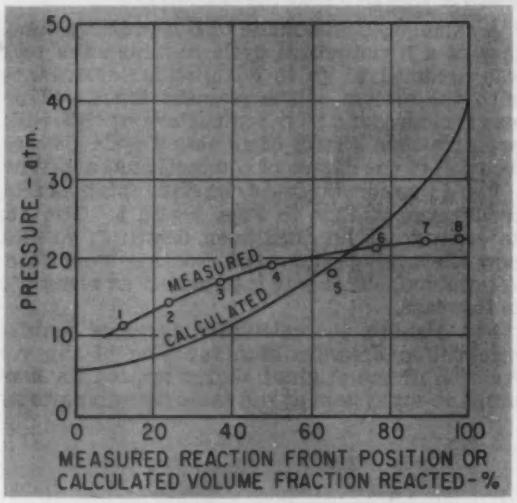

Fig. 5 — Comparison of calculated and actual pressure-reaction front positions for nitropropane at $\phi = 1.15$.

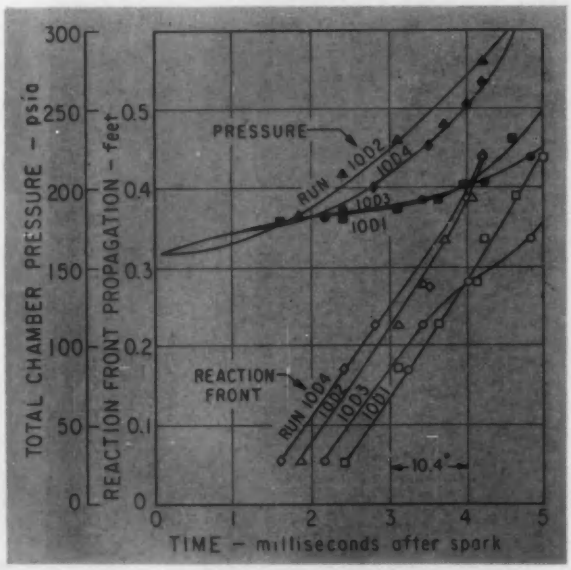

Fig. 6 — Pressure and reaction front histories for nitromethane at $\phi = 0.98$.

4. (The calculations and assumptions made in the construction of this curve are in the paper.) It is seen in Fig. 5 that at the end of an assumed adiabatic, constant volume combustion process the total chamber pressure would be 41.5 atmospheres or 610 psia. In the actual cycle the reduced data from Fig. 4 shows that at the point where the firing of the last ionization gap indicated that the reaction had traversed the complete chamber, the pressure was approximately 340 psia. Further analysis of the cycle showed that the peak pressure of 426 psia was reached 25 deg after top dead center. On the assumption that the burned products could be reversibly recompressed to top dead center, it was calculated that the pressure in the actual cycle would have been 580 psia if it had taken place at true constant volume. The difference between this pressure and the 610 psia calculated on the hypothetical cycle is due to heat transfer from the high temperature gases and to the fact that thermodynamic equilibrium was probably not attained in the short time available for reaction.

The calculated rate of pressure rise was approximately 100 psi/millisec while the maximum measured rate was 62 psi/millisec. This is further evidence then that the reaction was far from complete at the time the last ionization gap indicated that the entire mixture had begun to react.

Cycle to cycle reproducibility

Fig. 6 shows the reduced data from four cycles taken within a period of 2 min during which the engine operating variables remained constant. The average reaction front propagation rate is fairly constant for the four cycles, but there is an appreciable difference in the time lag between ignition and the establishment of a regular reaction front. The rates of pressure development were highly variable, even though the apparent rate of reaction velocity was relatively constant.

A very important item to be concluded from these and similar data is the danger in accepting point-by-point or time-integrated indicator card diagrams as representative of any actual cycle.

Reaction front propagation rates

The values reported here suffer the same shortcoming as all flame speed data; they were determined with respect to the stationary cylinder head and are uncorrected for relative gas movement with respect to the head. However, the experimental technique used minimized the error introduced by this relative movement.

Early in this investigation it was concluded that the reaction front progressed across the chamber in three separate and distinguishable phases. First, there was a period immediately after the spark when the effective rate of propagation was very slow. For example, in Fig. 6 it may be seen that approximately two milliseconds or 40% of the total traverse time were required for the reaction to reach the first ionization gap, and this represented only 12% of the total distance. This was followed by a period in which the propagation rate was almost constant. During the third, and final phase, the rate either increased drastically, due to abnormal ignition of the end gases, or dropped off as the piston moved out on

the expansion stroke, lowering the density of the gases.

For all of the data presented in this report, therefore, the spark timing was set at 26 deg before top center so that the second portion of the process, when the propagation rate was constant, coincided as nearly as possible with the time when the piston was near top dead center. At this point the reaction was as near to propagating into a constant volume chamber as possible and minimum mass movement of the gases due to external sources would be expected.

The reaction front propagation rates as a function of equivalence ratio for the fuel-air systems investigated are shown in Fig. 7. All of these data were taken from records similar to Figs. 4 and 6.

It is seen in Fig. 7 that for each fuel studied a definite maximum of reaction front propagation rate was noted as a function of equivalence ratio. For the nitroparaffin family the peak was near $\phi = 1.0$, while for isooctane and methanol, the peaks came at $\phi = 1.15$ and $\phi = 1.45$ respectively. It was found that methanol had the highest normal rate of reaction front propagation, 180 ft/sec. The value for isooctane was found to be 98 ft/sec at $\phi = 1.0$.

The most interesting result of this part of the experimental work was the fact that the nitroparaffins did not demonstrate the expected high rates of reaction front propagation as was originally thought, from their predilection to preignition. Neither did methanol give results as expected. The tendency for the respective fuels to attribute to disproportionate rates of pressure rise is therefore not related to the rate at which the initial reaction is progressing across the combustion chamber.

To Order Paper No. 83V . . .
. . . on which this article is based, turn to page 6.

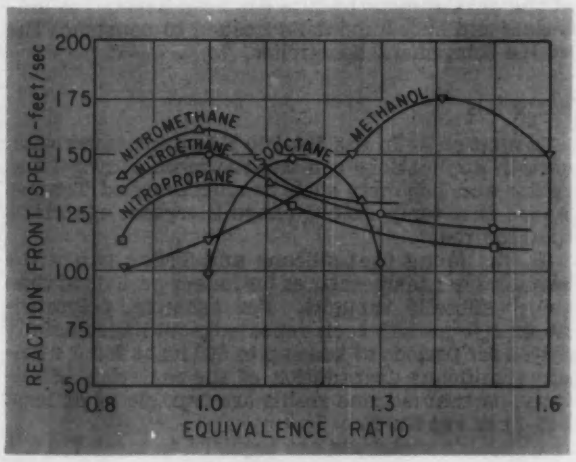

Fig. 7 — Reaction front speeds.

Selecting Materials For Missile Bearings

Based on paper by

ROBERT T. WESTMORELAND and PATRICK J. HANIFIN, North American Aviation, Inc.

MATERIALS for self-aligning, antifriction bearings capable of operating in temperature environments ranging to 800 F and to 1500 F, and accommodating radial loads up to 130,000 lb, were selected through test to meet the requirements of the Navaho missile system.

After preliminary testing of many materials, 440 C stainless steel and Allegheny-Ludlum DBL-2 (a high-speed tool steel of M-2 classification) were tested for temperatures approaching 800 F, and titanium carbide (Kentanium K163A and K163B1) for the 1500 F environment. Since no satisfactory lubricant was discovered, it was decided to provide as much protection as possible to the bearings while missile control surfaces were operated under ground checkout conditions at moderate temperatures. Accordingly, Brayco No. 483 oil (Per MIL-C-6529A) was chosen which would dissipate at higher temperatures without harmful residue to impair bearing operation. Essentially, the bearings functioned without lubrication at operational temperatures.

Results of the test program, which may be used to further the development of high-temperature control surface bearings, were as follows:

1. For 800-F unlubricated roller bearings in short life, high-unit load applications, high-speed tool steel of M-2 classification, heat-treated to a Rockwell C hardness of 61–63, was adequate.

2. For 1500-F unlubricated roller bearings, titanium carbide of Rockwell C hardness 65–69 (room temperature) has strong possibilities and warrants further development.

3. As many bearing components as possible should be fabricated from the same material.

4. Bearings should be provided with as much internal clearance as control surface vibrational and flutter criteria will permit.

5. An escape route should be provided for wear products that build up within the bearing.

6. Bearing housings and shafts should receive major attention, especially when dissimilar materials are used from that of the bearing.

7. Life of high-temperature reciprocating bearings could be prolonged significantly by providing a nonreversing relative movement between races and rollers, so that bearings as a whole experience the reciprocating motion.

8. The damage pattern shown by the bearings indicates that once the rollers and races have adjusted (plastically) to one angular oscillation, the bearings cannot be expected to operate properly through a larger arc of angular motion.

To Order Paper No. 112U . . .
on which this article is based, see p. 6.

600 F Airborne Electrical System Is On the Way

Based on paper by

John J. Pierro

North American Aviation, Inc.

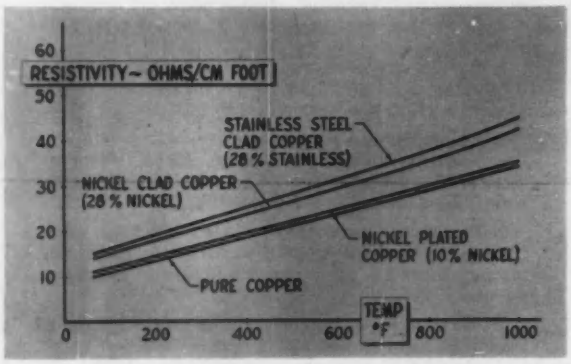

Fig. 1 — Conductor performance — increase of resistivity with temperature.

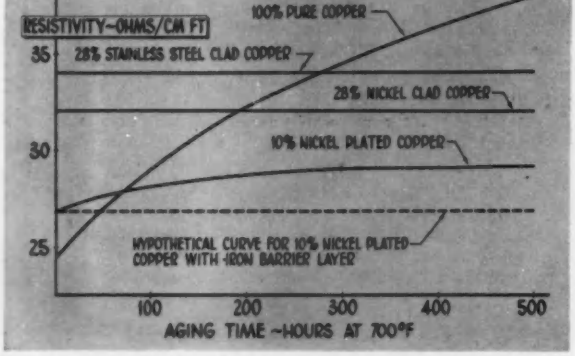

Fig. 2 — Conductor performance — resistivity versus aging time.

THE AIR FORCE has initiated a program to develop by 1962 a 600 F airborne electrical generation and distribution system. Based on the material, subcomponent, and component work done to date, there is little doubt that such a system is feasible. But major development work is still needed in some areas, such as semiconductor rectifiers and 1000 F flexible moisture-resistant insulation. Solutions are currently available for these in the 600 F region, but are marginal.

The basic 115/200 v, 400-cps three-phase a-c system is built around a 40-kva generator, with all other components operating from this system. The fundamental design requirements for the components are shown in detail in Table 1.

Each component must be designed to operate not only in a 600 F ambient, but also to function under other severe environments. The familiar shock, vibration, and acceleration requirements are more severe, and there are new factors such as acoustic noise and ozone.

There are twelve major components being developed by separate teams — North American Aviation is development manager of the total program. Most of the development to date has been devoted to materials and subcomponents needed to construct the major component assemblies.

Materials

Insulation — In the 600–700 F temperature region certain applications can use the more conventional resins and polymers such as silicones and Teflons. Above this temperature range inorganic materials are required.

It was found that silicone and Teflon can withstand higher temperatures for longer periods of time than generally thought. For example, polytetrofluorethylene has been repeatedly and successfully tested for periods of time up to 500 hr at 650 F without significant degradation of the material. Similarly, certain silicone resins are capable of at least 500-hr life at 600 F.

Inorganic materials are required to meet the hot spot temperatures up to 1000 F found in power

Table 1 — System Components and Fundamental Design Objectives

System Components	Design Objectives
Generator	40 kva, 3-phase, 400 cps
Voltage regulator	regulation, 2.5% total ambient temperature, 1% fixed ambient temperature; 0.2 sec recovery
Protective panel	overvoltage, undervoltage, differential current, torque limit
Constant speed drive	40 kva, 3000–9000 rpm input, 8000 rpm output
Speed regulator	±0.75% steady state regulation, ±0.25% frequency modulation, 1 sec recovery
Speed protection	2900 rpm input, 7600 rpm output underspeed; 10,500 rpm output overspeed
Transformer-rectifier	50 amp, 28 v output, 3-phase, 400 cps, 115 v input, 23 to 31 v regulation
Motor	0.05 hp, intermittent duty, 23,000 rpm
Motor	0.5 hp, continuous duty, 11,500 rpm
Motor	15 hp, continuous duty, 7,500 rpm
Wire (Type I)	600 F ambient, 650 F conductor, 22 and 12 gage single conductor
Wire (Type II)	600 F ambient, 850 F conductor, 22, 12, and 2 gage single conductor, cable of 3 No. 6 gage conductors
Wire (Type III)	850 F ambient, 1000 F conductor, 22, 12 and 2 gage single conductor, cable of 3 No. 6 gage conductors
Terminals	850 F ambient, 1000 F conductor, wire size 22, 12, 6 and 2 American Wire Gage
Fuses	28 v d-c and 400 cps, 115 v a-c, 1, 5, 60 amp, 4000 amp interrupting capacity
Circuit breakers	28 v d-c and 400 cps, 115 v a-c, 1, 10 and 100 amp single pole, 10 and 100 amp 3-pole
Contactor	175 amp, 3-pole, latch type, 4000 amp interrupting capacity
Current transformer	250/2 amp (125/1 ratio), 3% accuracy

equipment designs. The materials most used in the 700–1000 F temperature range are mica, glass quartz, alumina, refractories such as magnesium oxide or zirconium oxide, mixtures of the above in the form of cements, and to a limited extent, asbestos.

One very useful insulating medium widely used is fabricated from a layer of mica supported by a layer of glass cloth on one or both sides of the mica. The glass cloth provides mechanical strength, while the mica provides the electrical properties.

There are two important deficiencies of inorganic insulations — lack of resiliency, and porosity that makes moisture-proofing difficult. The most difficult insulation problem — so far without solution — is flexible moisture-proof insulated wire capable of withstanding 1000 F without a metal jacket.

Conductors — Silver and copper are the only two practical conductors for the applications considered. The high cost and high density of silver make it undesirable where large quantities are required — although it is in many respects an ideal conductor for high temperature.

Copper has been generally adopted. . . . But it has a severe oxidation problem in the 600–1000 F temperature range.

To prevent oxidation with minimum increase in resistivity, the copper is coated with another material. Nickel and stainless steel are used most, although inconel is also used.

The problem is to apply a minimum thickness, since thickness is reflected directly in terms of resistivity, and ultimately as weight.

Most recent work has been aimed at coatings of 5–10% by weight of the total conductor, compared to earlier coatings of 30%. The lighter coating allows an increase from approximately 70% conductivity (IACS) to 90%. The performance of several protected copper conductors is shown in Figs. 1 and 2.

A problem introduced by the use of protective coating is mixing and diffusion between it and the copper. This produces a band of an alloy at the junction of the two metals, which grows with time, and increases resistivity. A boundary material relatively inert to both copper and the protective coating has been used effectively to minimize this effect.

Magnetic Steel — The most satisfactory material to date is a cobalt-iron alloy which demonstrates excellent square loop characteristics, high flux densities, and high Curie temperatures. It is still in development. The nickel-iron alloys generally used are not satisfactory above 600 F because of signficant temperature effects due to low Curie temperatures.

Subcomponents

Resistors — Two types of resistors are available for use at high temperature — wire wound and film. The film types are more compact although less accurate. They are used for low-wattage (under 2 w) applications where a temperature effect of less than 5% isn't needed. They are especially well adapted to very high resistance areas in which the wire wound becomes very bulky.

Wire wound is used when high accuracy and high power are needed. Resistors having a temperature effect of 1% are available — even less temperature effect can be obtained by matching two resistors with plus and minus coefficients.

Important areas for future development are decreasing temperature effect on film types, and decreasing bulk.

Capacitors — Performance of capacitors which use

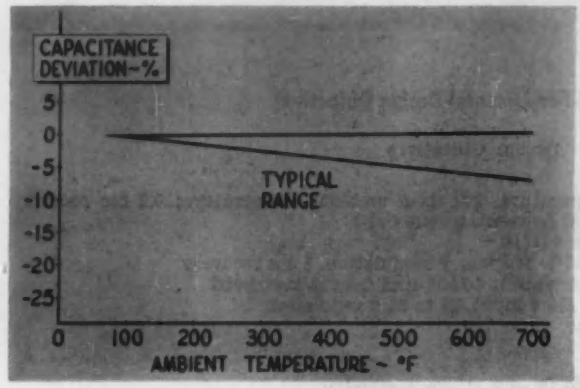

Fig. 3 — Mica paper capacitor performance — capacitance deviation over temperature range.

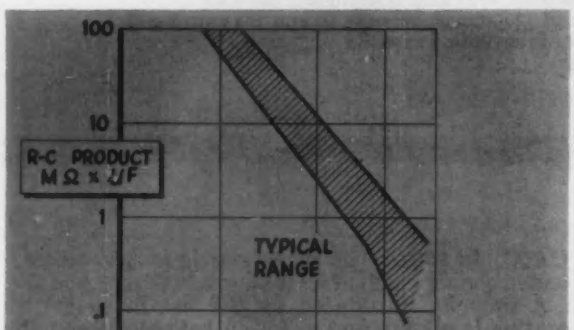

Fig. 4 — Mica paper capacitor R-C product over temperature range.

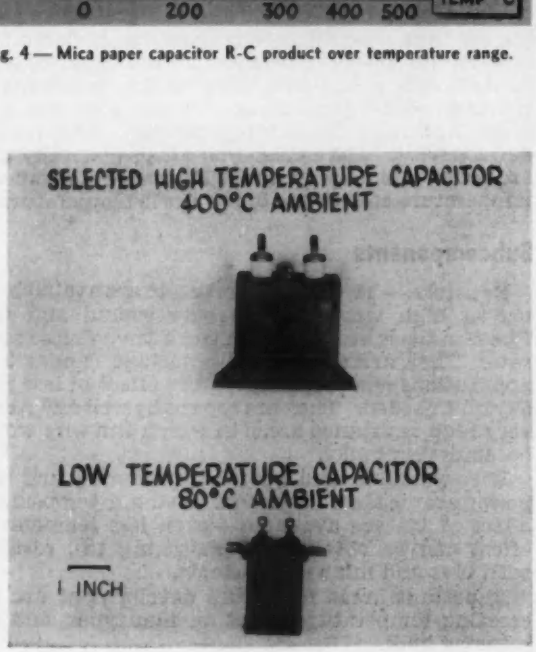

Fig. 5 — Size comparison of high- and low-temperature capacitors.

mica as the dielectric material is shown in Figs. 3 and 4. About a 5% change in capacitance can be expected over the temperature range, and the megohm-microfarad product decreases to a range of 0.1–1 at the upper temperature extreme of 842 F (450 C).

This type of capacitor has a large volume — 10–15 cu in. per microfarad — certainly an undesirable penalty. Fig. 5 compares high- and low-temperature capacitor size.

A smaller, lighter capacitor is necessary. . . . Film type capacitors have the greatest potential. They use dielectric materials which are applied in very thin films to the capacitor conductors by evaporation or flame spraying. Under development is a capacitor with both conductor and dielectric applied in thin films. Bulk factors of 0.5–2.0 cu in. per microfarad are expected.

Transformers — Transformer size and weight must also be reduced. Available transformers (Fig. 6) depend on a sealed metal can to provide moisture protection and mechanical strength. These transformers have been operated successfully for 1000 hr at 1000 F.

They are suitable for the specific program under consideration, but an open design of lighter weight construction is desirable for the future. The big problem is finding a suitable impregnating and potting compound capable of withstanding mechanical and thermal stresses and preventing the entrance of moisture at lower temperatures.

Rectifiers — Gas rectifiers can operate in a 600 F ambient. But they are bulky and relatively inefficient.

High-temperature semiconductors are currently under development. Gallium arsenide, gallium phosphide, and silicon carbide have received the most attention.

The first two are more feasible for a range of – 65 to 600 F. Gallium phosphide is best for the highest temperature applications because its temperature limit is 900 F versus 650 F for gallium arsenide. (These limits are not firmly established.) Both are expected to be roughly comparable to low temperature units in size but voltage drop may be higher.

Silicon carbide rectifiers will have high-temperature capabilities considerably above either of the other two, but are not expected to have satisfactory low-temperature performance. So they are valuable only for continuous high-temperature use. Fig. 7 is a typical package for a 0.5 amp 75 v peak inverse voltage rectifier.

If semiconductor rectifiers prove unfeasible or not available in time, gas rectifiers will be used. They will probably be similar to ceramic vacuum tubes now in use.

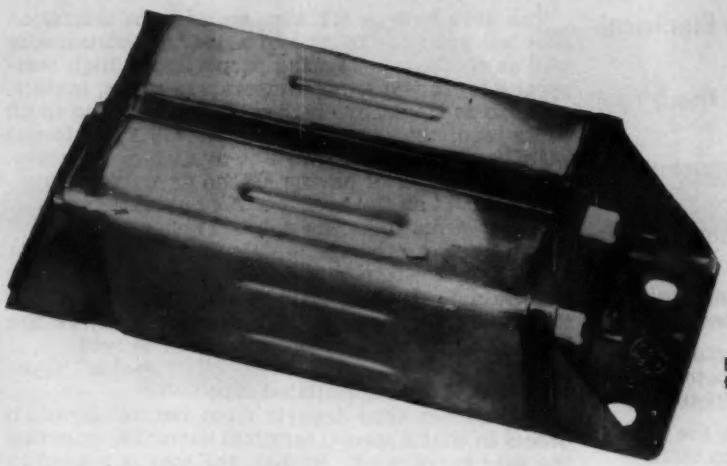

Fig. 6 — High-temperature transformer.

Tubes — Vacuum tubes capable of operating for 500 hr and longer at 650 F are available — the tubes most widely used are of a planar construction shown in Fig. 8. This stacked construction uses ceramic "washers" to separate the tube elements with seals at each junction between ceramic and metal, resulting in very rugged construction.

A voltage reference tube is being developed for use as a voltage regulator. It will also utilize a planar, stacked construction, as shown in Figs. 8 and 9. Although still in the experimental stage, it is already satisfactory for regulation over the −65 to 750 F range.

A gas diode aimed at approximately 0.2 amp is also under development (Fig. 9). This will meet the need for a rectifying element which has a very stable forward drop with temperature. It is also capable of withstanding peak inverse voltages over 150 v. Semiconductor rectifiers will not fill these needs.

Magnetic amplifiers — The magnetic amplifier is formed by coupling a saturable reactor with high-temperature rectifiers and other high-temperature components. Major problems are in obtaining consistent material parameters from developmental batches of magnetic material (discussed earlier in paper) and in proper packaging of cores to protect against mechanical stress and thermal effects.

Innovations in Major Component Designs

Generator (General Electric) — Called the "inductor-Lundell" design, it features a rotor that doesn't require windings. The flux is generated on the stator, hence eliminates the need for electrical current flow on the rotor — and with it, the need for slip rings or rotating rectifiers. This has distinct advantages for high-speed operation and increased reliability at high temperature. Excellent rotor balance can be achieved and the normal high stress on rotor windings and insulation are eliminated. Rotor cooling problems are solved, too. Fig. 10 shows the rotor design, and Fig. 11 the partially disas-

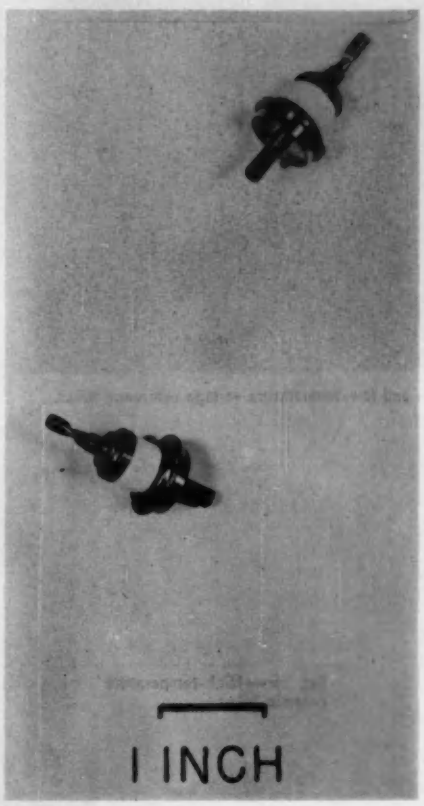

Fig. 7 — Silicon carbide rectifiers — ½-amp 75-v peak inverse voltage.

600 F Airborne Electrical System Is On the Way

. . . continued

sembled generator. A full high-temperature version is currently under construction.

Wire (Electric Auto-Lite and Lewis Engineering) — Three types of wire are being developed:

Type I — 600 F ambient, 650 F conductor
Type II — 600 F ambient, 850 F conductor
Type III — 850 F ambient, 1000 F conductor

Type I and Type II wire developments are nearly complete and are undergoing qualification tests.

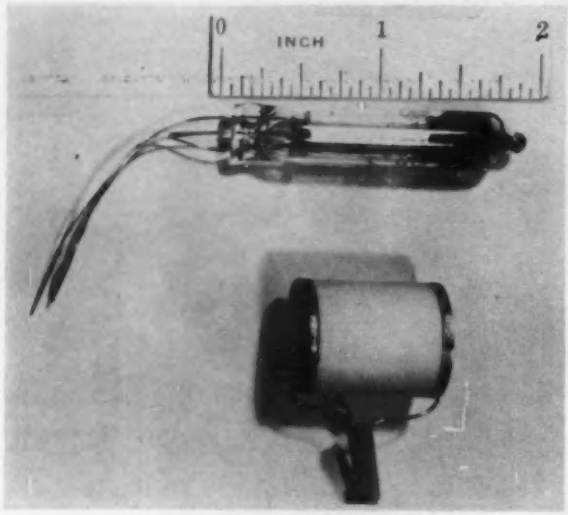

Fig. 8 — High- and low-temperature voltage reference tubes.

The 1000 F Type III wire requires an insulation that has good flexibility and moisture resistance as well as excellent insulating properties at high temperature. In the lower temperature range, materials such as vinyls, nylons, and Teflon are used to fill these requirements. Above about 650 F, materials with these properties are not available. Development of a material having all the desirable characteristics isn't on the horizon. A combination of materials appears to be the only feasible approach . . . possibilities are ceramics, glass, quartz, and a non-insulating moisture barrier.

Terminals (Burndy Corp.) — Terminals to match the 1000 F maximum conductor temperature are being developed. Two designs have emerged.

One is a new concept called the "washer" type; the other is a post insulated type.

The washer type departs from normal terminal design in that a special terminal barrel for crimping the wire is not used. Rather, the wire is housed in the tongue of the terminal and held in place by a special crimp. Fig. 12 shows a 22 gage washer terminal compared with a normal terminal. A very short, small terminal results. . . . The absence of a terminal barrel eliminates the possibility of shorting across the barrels and also the protrusion beyond terminal block covers that normally occurs. . . . Because of these features, an insulated terminal is not required. Unfortunately, this design is only applicable to smaller gages and beyond 16 or 14 gage the terminal becomes too thick for normal use. For gages larger than this, a more normal design utilizing a terminal barrel has been adopted. Lack of a suitable, flexible high-temperature insulation has prevented a preinsulated approach, and an assembly consisting of terminal and insulated sleeve has resulted. The two parts are permanently joined together at manufacture so that the insulated sleeve may be slid back out of the way while the wire is mechanically crimped, then slid back over the wire barrel to be permanently locked in place. In both cases, potential problems with high voltage drop across the crimp and bolted joints have been avoided by the use of special platings and optimum crimps.

To Order Paper No. 102V . . .
. . . on which this article is based, turn to page 6.

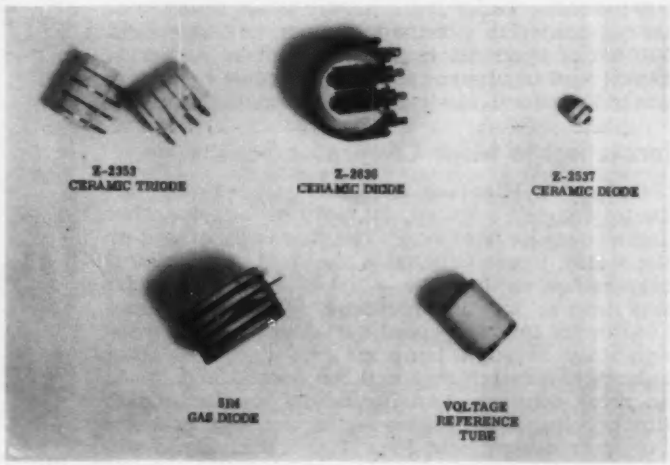

Fig. 9 — High-temperature ceramic tubes.

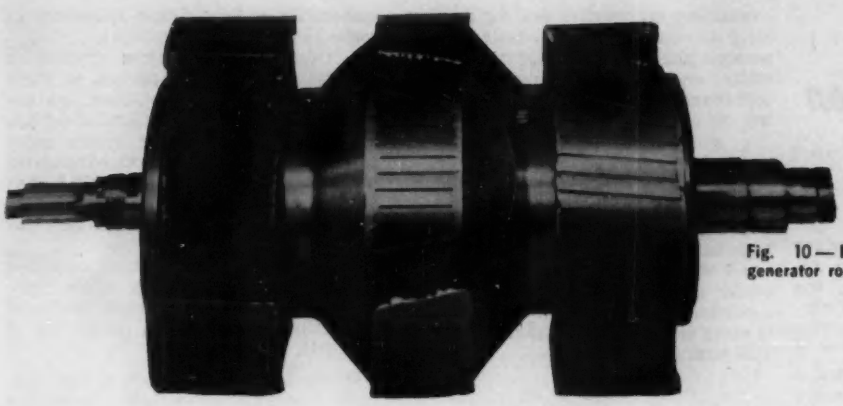

Fig. 10 — Inductor-Lundell generator rotor.

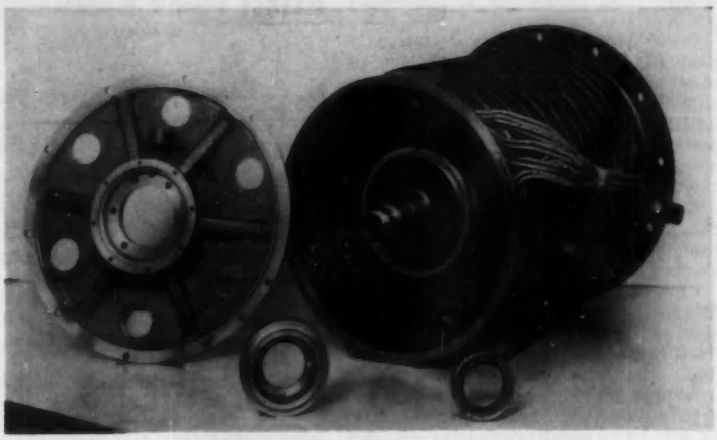

Fig. 11 — Inductor-Lundell generator, partially disassembled.

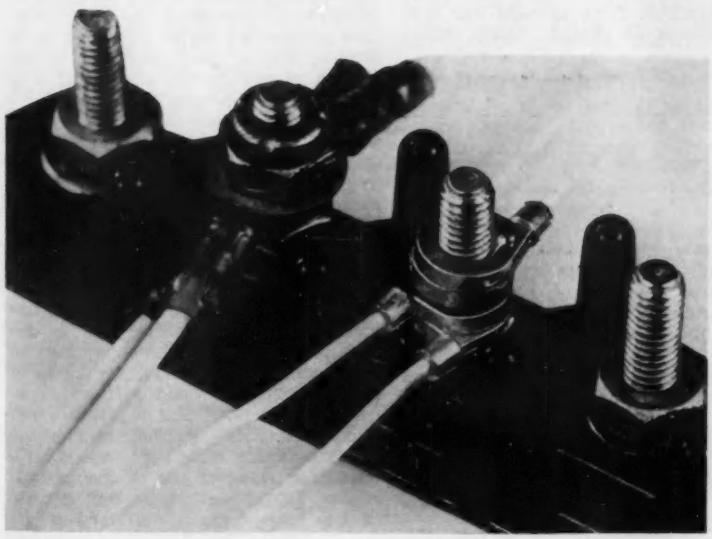

Fig. 12 — Washer terminal compared with standard terminal — 22 gage.

Program Study Ride and Vibration

As reported by

SAE Riding Comfort Research Committee

A LITERATURE and research survey on vehicular ride and human response to vibration conducted by the SAE Riding Comfort Research Committee revealed the following programs in process:

Bostrom Research Laboratories — Developing for the Surgeon General's Office the reaction of the human body in terms of stress measurements (pulse, blood pressure, perspiration content, and metabolism — Fig. 1) comfort reactions, and mechanical response when subjected to sinusoidal bidirectional motions.

Ohio State University — Currently studying physiology and pathology of rats and dogs when subjected to sinusoidal vibrations in both vertical and horizontal planes. Physiological and psychological performance tests on man were scheduled to start on July 1, 1959.

Cornell Aeronautical Laboratories — Studying the influence of vehicle parameters and dynamics on the dynamic loading to road surfaces.

Chevrolet Engineering Center — Measuring progress in suspension design, especially in trucks, and developing a ride index. Vertical, fore and aft, and lateral accelerations are being measured on the head of a seated individual and on various parts of the vehicle. The accelerations are recorded on magnetic tapes for processing and analysis. These measurements are being made on passenger cars, ½-ton and 2½-ton trucks with different types of seating. The tests are not directed at measuring small changes in suspension, but rather the direction of the changes.

Rockwell-Standard Corporation — Developing an electronic means of evaluating automotive seating particularly as related to human fatigue. The present phase of the program is essentially one of developing measuring techniques. Among the equipment being developed or employed are:

1. A means of recording pressure points on the seated individual.
2. A means of measuring blood flow at the various seated pressure points.
3. A means to measure muscle potentials using an oscillograph.

All of the present work is being done under static conditions. Preliminary results appear to indicate that the body is more sensitive than the mind to outside stimuli.

Turbine Fuel Variables Affect Flame Radiation

Based on talk by

N. P. Randall and W. F. Ritcheske

Texaco Research Center

STUDIES of the effect of fuel variables on radiation from flames in a turbojet combustor showed that:

1. The composition and physical properties of aircraft turbine fuels greatly influence the amount of radiant energy emanating from the combustion flame, and this in turn has a large effect upon the temperature of "hot parts" of the engine (and consequently its service life).
2. Aromatic and naphthenic compounds degrade the performance of turbine fuels as regards flame radiation tendencies. Aromatics are more deleterious than naphthenes, and the presence of one amplifies the effects of the other.
3. Paraffinic fuels provide the best performance as regards flame radiation.
4. Fuels of lower boiling range may materially reduce flame radiation in some gas turbine combustors.
5. Of the various ways studied to correlate physical properties of fuels with flame tube temperatures, the use of relatively simple functions of refractive index and density seems quite promising. This was not an exhaustive study, however, and it is possible that further efforts would produce simpler functions and/or more precise correlations.
6. A lamp-type apparatus equipped with a radiation detector offers considerable promise as a simple means of predicting the radiation properties of jet fuels.

About 30 fuels were used in this program, including JP-4 wide-cut turbine fuels and kerosenes typical of current production, aromatic fuels and blends, commercial-grade hydrocarbons, and paraffinic fractions.

Combustor tests were conducted in a 4-in. diameter laboratory combustor and in two modern full-scale combustors.

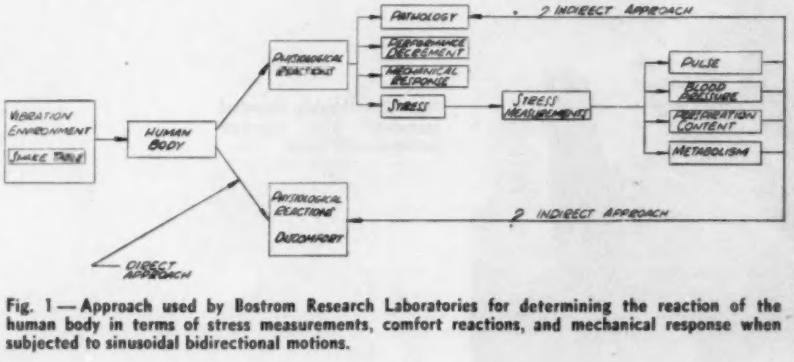

Fig. 1 — Approach used by Bostrom Research Laboratories for determining the reaction of the human body in terms of stress measurements, comfort reactions, and mechanical response when subjected to sinusoidal bidirectional motions.

Hi Fi Dynamometer Testing By Tape Programming

Based on paper by

Vern C. Vanderbilt, Jr.

and

Clarence L. Zimmer

Perfect Circle Corp.

THE FIDELITY of programmed dynamometer testing depends on the method of obtaining and using the program in the control of the engine on the dynamometer. If the program is obtained by recording the actual engine parameters under real road conditions, and is then used for direct control of the engine, the result is a most effective testing system.

A magnetic tape is an inexpensive way to store information, but it requires that the information be coded in in one of a few specific forms. The form chosen was a frequency modulated (FM) a-c signal, and a transducer was used to transform the particular parameter into the signal recorded on the tape.

The spacing of the magnetized domains on the magnetic tape is determined by the frequency applied to the recording head and the velocity of the tape over this head during the recording process. Thus, a distance between similarly oriented magnetized portions of the tape corresponds to a particular value of one of the parameters. The deviation of the velocity of the tape from a standard would

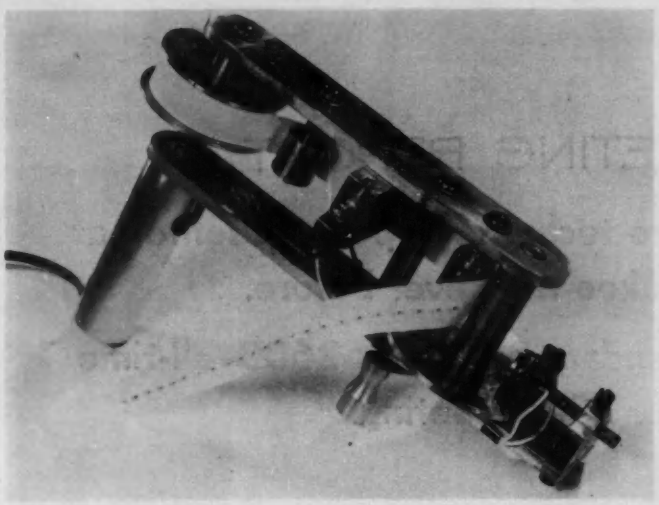

Fig. 1 — Model of a device to provide compensation for inaccuracy caused by deviation in tape velocity during recording or reproducing.

produce an error either during the recording or reproducing process.

Since the recording process is done in the vehicle with a portable power source, some means of frequency correction or compensation is necessary if accuracy is to be maintained in the narrow FM bands.

A device to provide the necessary frequency correction is shown in Fig. 1. The model is intended to represent a tape recorder and a device to convert a displacement signal into a frequency. The paper tape represents the magnetic tape, the solenoid the record head of a recorder. The rubber roller and engaging shaft represents the pinch roller and capstan of a recorder.

The signal which energizes the solenoid is made by contacts on the small wheel driven by the disc. The wheel turns with the disc and causes the contacts to make and break. As long as the wheel remains at the same radius on the disc, the spacing of marks on the tape remains constant regardless of tape speed since both tape velocity and disc speed are synchronized.

The device converts a displacement along a radius of the disc to a fixed spacing of magnetic domains. In other words, the wheel position on the disc is proportional to a certain frequency when the recorded tape is played back, using a standard line frequency to drive the recorder. If the displacement of the wheel is made proportional to manifold air pressure, a pressure to frequency transducer results. Similarly, if the wheel position is made proportional to temperature by means of a vapor bulb thermometer, a temperature to frequency transducer results.

To Order Paper No. 69V . . . on which this article is based, see p. 6.

Tyrex Tires Excel In Severe Road Test

Based on paper by

G. M. Sprowls

Tyrex, Inc.

(Presented before SAE Indiana Section Meeting)

TIRES constructed with Tyrex viscose cord outperformed nylon and rayon cord tires in an impact resistance test conducted over Nevada terrain, which combined pavement travel with moderate to heavy impact conditions on a secondary road. Results are shown in Table 1.

The test was made with four station wagons, each equipped with one tire from four types — (A) Tyrex 1100/2 (14 × 14), (B) Tyrex 1650/2 (12 × 12), (C) nylon cord 840/2, and (D) rayon cord 1650/2 (12 × 12). Each set of tires was distributed over all four wheel positions, and the position of the cars in the convoy was rotated each day. Rock outcroppings were painted and drivers instructed to drive over them so that all four sets of tires were subjected to identical treatment.

After an initial tire break-in of 500 miles at 65 mph for all tires, the cars were driven 120 miles per day on highways, then 28 miles on the secondary road. The test began with all tires at 100% load and recommended inflation pressure, with a 10% increase daily until 130% was reached. The first impact break occurred at 130% load and the remainder of the test was run at this load. The test of any group was ended at 5000 miles or when five tires in that group had failed from impact or bruise breaks.

The tires replacing those that failed, and had not the benefit of the 10% step load increase, failed at a lower mileage than the original equipment. Tire mileages of original applications presented in Table 2 show better totals being rolled up by the Tyrex viscose cords. Although the test has its statistical limitations, it is felt that the testing of a larger number of tires would not have changed the trend in results, although it might have shown more variation between groups.

To Order Paper No. S203 . . . on which this article is based, see p. 6.

Table 1 — Impact Performance Comparison

A — Tyrex, B — Tyrex, C — Nylon, D — Rayon

	Number of Tires	Impact Failures	Other Failures
Front Wheels			
A	2	0	0
B	2	1[a]	0
C	4	0	2
D	4	1	1
Rear Wheels			
A	10	2	5
B	6	1	2
C	8	5	2
D	8	4	2
All Wheel Positions			
A	12	2	5
B	8	2	2
C	12	5	4
D	12	5	3

[a] Break indicating eventual failure

Table 2 — Original Test Tire Performance

A — Tyrex, B — Tyrex, C — Nylon, D — Rayon

	Total Tire Mileage	Impact	Cut	Number of Failures
Rear Wheels				
A	4194	1	1	0
B	5345	1	1	0
C	3268	2	0	0
D	3193	1	1	0
Front Wheels				
A	10,004	0	0	2
B	9998	1	0	1
C	7255	0	2	0
D	4326	1	1	0

Oil Seal Provides Own Running Surface

Based on paper by

R. A. HUDSON

Chicago Rawhide Mfg. Co.

A TYPE OF OIL seal has been developed for truck wheels in which the surface on which the seal runs is incorporated in the assembly. This design makes it unnecessary for the user to be concerned with the finish, hard-

continued on p. 138

SAE FCIM MEETING REPORT

- **More technical papers presented at Milwaukee than ever before.**
- **Attendance exceeds 2600—all-time high for FCIM meeting.**

MIXING learning and fun, SAE members attended and participated in 9 production panel sessions, 8 technical sessions (featuring 25 technical papers), a Powerama Picnic — Spectacular, a plant tour, a luncheon, and a golf tournament at this year's SAE National Farm, Construction, and Industrial Machinery Meeting and Production Forum.

The production sessions included discussions of: Production Planning and Control for Profit, Cost, and Service Improvement; Planning–Organizing–Controlling the Administrative Function; Heat Treating Techniques; How to Prepare Engineers for Management; Engineering-Purchasing Relationships; Welding Methods and Process Control; A Complete Quality Control Program; Applying Automation Under Today's Operating Conditions; and Cost Saving Ideas or Cost Reduction for Survival. Capsule descriptions of all the Production Forums are given on pp. 92–93.

Technical sessions covered: Soils Compaction; Ripper vs. Powder Blasting; Economics of Future Farming; What's New in Transmissions; Russian Progress in Agriculture; Design and Rating of Cranes; Power Take-Off Drive Lines; and Hydraulic Lift Systems and Implement Hitches. Abridgments of all the technical papers are given on pp. 86–92.

The Powerama Picnic — Spectacular held many treats for SAEers. An Air Force ground support equipment demonstration; a display of U. S. Army Corps of Engineers standard engines, engine accessories, and construction equipment; Brooks Stevens' antique cars; a Navy band, Air Force drill team, Marine Corps escorts; and, of course beer and box lunch — all played a part in making this picnic-type luncheon one of the best attended events in all SAE history.

An SAE plant tour to the Oak Creek Plant of A. C. Spark Plug Co. also received wide support. Members watched worker and machine manufacture inertial guidance systems for the Thor, Mace, and Titan missiles.

An overflow crowd attended the annual FCIM Luncheon. All came to hear the views of Marc B. Rojtman, president, J. I. Case Co., on "Can the United States Compete with European Manufacturers?" A box on p. 88 summarizes Rojtman's thoughts on this timely topic.

The Production Forum panels were arranged under the leadership of General Chairman R. A. Dimberg, manager, industrial engineering, Allen-Bradley Co. Forum Sponsor was I. F. Herbes, works manager, Allen-Bradley Co.

Programs for the technical sessions were planned by a committee headed by General Chairman E. H. Panthofer, vice president, Perfex Corp.

Others responsible for arrangements for the Meeting included Robert Cramer, Jr., reception; Giles Smith, attendance promotion; F. J. Hartshorn, publicity; and Quentin O'Sullivan, public relations.

Capsules of FCIM Technical Papers

LIMITATIONS OF SOIL COMPACTION EQUIPMENT — It is generally believed that while static rollers can be used affectively on partially saturated soil of almost any type, they are most effective on soil containing at least a certain amount of cohesive binder material. They are least effective on coarse graded cohesionless soil and base course materials. For materials of the latter type, vibratory rollers and tampers are being used to an increasing degree. (Paper 89T)

COMPACTION OF HIGHWAY EMBANKMENTS — There is a need for agreement on the basic concepts involved in the compaction of highway embankments and surfaces. There is considerable uncertainty as to the practicability of specifying any numerical density requirement until the moisture-density strength relationship has been determined for job conditions. Agreement on basic concepts could lead to the adoption of more uniform and realistic requirements for density or supporting value and a greater standardization of equipment performance requirements. (Paper 89U)

STANDARDS FOR COMPACTION EQUIPMENT — Initial equipment cost and the cost of operation and maintenance are the points on which earthmoving contractors evaluate compaction equipment. The type of compactor which will meet current construction requirements depends on the location and the soils of each job.

The universal appeal of earthmoving contractors is for standardization. At present, the individual contractor must determine the piece of equipment which will best compact the soil on a given project. Standardization would eliminate the necessity of holding large varieties of equipment on a job. (Paper 89V)

TRACTOR-MOUNTED RIPPERS — Factors to consider when comparing ripping with drilling and blasting are:

1. Where ripping can be done on a production basis, it generally can be done at a lower unit cost than by drilling and blasting.

2. Desired specifications of the material as determined by its end use should be considered when choosing a method of loosening consolidated material.

3. Requirements imposed by the equipment used to transport the material will influence the decision — to drill and blast or to rip?

Some of the most important design factors in ripper performance are: type of linkage, selection of design load, ripping ange and depth, point design, and properly matched hydraulic components. (Paper 90T)

EFFICIENT RIPPING A MATTER OF PROCEDURE — To obtain the ultimate in ripping, a contractor should:

1. Get the two largest available

R. A. DIMBERG, general chairman of the Production Forum, opened the business session at the Production Breakfast. Seated (left-to-right) are: W. F. Shurts, meetings vice-chairman, Farm, Construction, and Industrial Machinery Activity Committee; I. F. Herbes, Production Forum sponsor; and F. P. Steiner, vice-president, FCIM Activity Committee.

E. H. PANTHOFER, general chairman of the Meeting, welcomed Meeting participants.

single-engine, direct-drive tractors.

2. Fit each with narrow blade, hydraulic bulldozers.

3. Fit each with integral back-mounted hydraulic rippers, without teeth or shanks. Strengthen and gusset the structure properly to take the power of two tractors without damage.

4. Fit one tractor with heavy-duty, special pusher and shank bracket in the center hole of the ripper body.

5. Fit the other tractor with two of the special brackets, **one at each outside end** of the ripper body. (Paper 90U)

BLAST OR RIP? — For the explosive industry, there is no known rock that cannot be broken by blasting — from the softest shales to the extremely hard taconites and granites. It is only the extremely low end of this range of rocks that can be economically ripped. However, when the choice of methods exists, the decision to rip or blast depends on only one question — which is the most economical way to get the job done.

Total costs of both systems must be considered, not just operating costs. (Paper 90V)

THE FUTURE IN FARMING — By 1975 the number of commercial farms, which now produce nearly all our farm products for sale, will be about 2 million as compared with around 3 million today. The commercial farm of the future will be larger in acres, much larger in production, and more specialized. This increase in production per farm will be attained partly by more acres per farm, but primarily by wider use of improved methods to increase production per acre, per animal, and per man.

The commercial farm of 1975 will be essentially a business proposition. The high capital requirements will create new problems in financing and in transferring farms from one generation to the next. (Paper 91T)

MECHANIZATION ON THE FARM — Three areas of agricultural mechanization are of importance: major field crops, special crops, and farmstead mechanization. In the first area, improvements in production will be made by changes in techniques rather than with completely new machines (for example, new methods of planting, harvesting, pesticide control).

Fruits and vegetables are only two of the crops that still require a great deal of hand labor. Machinery to handle these crops is being developed.

In the area of farmstead mechanization, increasing use will be made of analytical and experimental means for determining the best possible solutions to farm operations. (Paper 91U)

ELECTRIC DRIVE FOR OFF-HIGHWAY VEHICLES — The concept of an electric motor mounted inside the rim of a large wheel provides new standards of flexibility and performance in off-highway vehicles. Its weight and cost reductions over conventional electric drive schemes make electric power application to a number of wheels, and the resulting increased braking capacity, economically feasible in large vehicles. Moreover, the motorized wheel vehicle will fit easily into established operating and maintenance patters. The devices for operator control can be arranged to require only slight physical effort and practically no need for retraining when switching from a vehicle with mechanical transmission. (Paper 92T)

HYDROSTATIC TRANSMISSION — The "hydrostatic" type transmission transmits power by means of fluid under pressure acting upon a moving piston. Energy is imparted to a fluid by a positive displacement pump and is transmitted to a positive displacement motor, where it is converted into

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Papers on which these capsules are based are available in full in multilith form. See order blank on page 6.

At the Luncheon

Marc B. Rojtman (center), president, J. I. Case Co., meets SAE President Leonard Raymond (right) as Fred S. Mackey, vice-president, manufacturing, A. O. Smith, Corp., looks on. Rojtman was guest speaker at the luncheon and Mackey was the toastmaster.

In his speech, Can the United States Compete with European Manufacturers?, Rojtman said, "American industry will have to roll up its sleeves and again demonstrate the vitality of its pioneer spirit if it is going to lick the problem of gradually becoming noncompetitive with European manufacturers." Constant product refinements and new product design, combined with lower production costs, are the only answer to regaining our competitive position, he said.

Rojtman, who recently completed several trips to Europe, stated, "The thousands of new plants that are now going up in Great Britain, France, Germany, and Italy must simply be seen in order to visualize and evaluate the huge competitive strength they already represent, and particularly the manufacturing strength and price competition they will represent at their peak — just a few years from now."

In order to survive and maintain our competitive position, he concluded, the United States must cast aside complacency and pit all its engineering genius and high production skills against the remarkable industrial re-awakening of Europe.

FCIM Meeting

. . . continued

useful work. The advantages of the system are:

1. The input end of the transmission can be designed to deliver an infinitely variable quantity of fluid.
2. It is fully reversible.
3. It has high efficiency over a wide range of operating conditions.
4. Extremely precise control in both vehicle speed and vehicle travel is possible.
5. It can accelerate, decelerate, or reverse direction faster than any other type of power-transmitting system.
6. It offers flexibility of installation.

The major disadvantage is that there are no high-performance hydrostatic transmissions commercially available today that can compete directly with other forms of mechanical transmissions on a dollar per horespower basis. Noise and weight are other problems. (Paper 92U)

HYDROSTATIC TRANSMISSION FOR VEHICLES — The advantages of hydrostatic transmissions are:

1. The ability to operate efficiently over a wide range of torque speed ratios and to reverse rotation at a controlled rate which is unaffected by the value and direction of the output load up to a limiting maximum torque.
2. The ability to remain stalled under full load without damage and with a very low power wastage.
3. The ability to hold a selected speed ratio accurately against driving or braking torques up to pre-set limiting values. The ability may be limited by a simple automatic overriding controls where desirable.
4. The ability to produce more torque for less space and weight and with less inertia than any other type of remote actuator transmission.
5. The ability to transmit power without the vehicle layout limitations imposed by a mechanical drive line. (Paper 92V)

HYDRODYNAMIC SPLIT TORQUE TRANSMISSIONS — Split torque arrangements are recommended for transmissions where: (1) economy ratio is important and lower availability and stall torque ratios can be accepted (true splits); (2) increase of stall torque ratio only is desired (positive recirculative systems); and (3) planetary or differential gears can be used for other purposes as well.

The transmissions are not recommended where availability ratio is important or where extreme simplicity of design is needed. (Paper 92W)

RUSSIA'S SEVEN-YEAR PLAN FOR AGRICULTURE — In Russia's long-range planning, as incorporated in the recently announced seven-year plan, some of the general goals and technical projects in agriculture are:

1. Increase electrical power on farms 2½ times, compared to the last six years.
2. Through increased mechanization, double farm labor productivity on collective farms and increase it on state farms by 60–65%.
3. Use 35 million tons of chemical fertilizer, compared to 12 million tons in 1958.
4. Continue to expand grain growing as the basis of all agricultural production.
5. Develop machinery to mechanize the cultivation of certain crops, such as cotton, sugar beets, potatoes.
6. Expand transport facilities.
7. Further mechanize the animal husbandry industry in order to expand the output of meat, milk, wool, and eggs.
8. Build more mixed-feed factories.
9. Manufacture more land reclamation machinery, equipment for materials handling, and machines for the extraction of peat, lime, and other local fertilizers.
10. Increase the output of spare parts and improve the quality of machinery parts. (Paper 93T)

TRACTORS IN THE U.S.S.R. — Farm tractors in the Soviet Union fall into three general classes:

1. Older tractors, built before and in the years immediately following World War II, the design of which closely follows that of their U.S. prototypes. In the case of wheel tractors, their manufacture was abandoned as soon as new designs could be placed in production following the war. With the exception of the large crawler tractors built in Western Siberia, which follow the design of an early American tracklayer, these earlier tractors were powered with carburetor-type en-

gines and burned either gasoline or distillate.

2. Present production wheel and diesel tractors, ranging from 18 to 54 hp, which are "genuine Soviet originals." These constitute the greater number of tractors now in use. Their power-to-weight ratio is low, specific fuel consumption high, and general design heavy-handed.

3. New models intended for 1959 production or later. These incorporate many distinctive and modern improvements, including increased power and power-to-weight ratio, lower specific fuel consumption, travel speeds better suited to the operation of higher speed implements, and greater operator convenience. (Paper 93U)

RATING LOADS FOR MOBILE CRANES — A rating formula cannot be devised to permit mobile cranes to be used at their real capability and still provide for the contingencies that arise from irresponsible operation. Thus, ratings become basically the means to compare machines, enabling the user to decide which crane best suits his operations.

It has been the users who have demonstrated the capabilities of mobile cranes and the extent to which these capabilities can be used safely. They have demanded that manufacturers follow their lead in developing machines with more and more ability within the limits of weight and dimensions required for easy mobility. (Paper 94T)

INDUSTRY ATTACKS PROBLEM OF PTO DRIVES — Various engineering societies (FEI, ASAE, and SAE) currently are cooperating on the problem of power take-off drives between agricultural tractors and implements. Projects under investigation are: (1) development of an improved hitch connection between the tractor and implement; (2) improvement in fastening for the forward universal joint to the tractor PTO shaft; (3) development of a standard covering the PTO drive shaft assembly; (4) improvement of the telescoping of the power line between the tractor and implement; and (5) the 1000-rpm PTO program. (Paper 95T)

STRENGTH CONSIDERATIONS GOVERN DESIGN OF AGRICULTURAL DRIVE LINES — The strength consideration is of major importance in any drive line. Provision must be made to accommodate the maximum force or forces that can be applied, whether it be a tractor transmission shaft, an unloading auger drive, or a combination harvester. Consideration must be given to the nature and magnitude of force applied: is it essentially static or steady, is it suddenly applied, is it fluctuating, or is it a combination of these? This information is necessary in order to select the proper material from the standpoint of size and manufacturing process. (Paper 95U)

FREE-TELESCOPING PTO LINES — Free-telescoping power take-off drive lines are advantageous in preventing: (1) collapse of the center bearing supports, (2) excessive thrust loads on the crosses and on the tractor and machine bearings, and (3) drag or seizure of the telescoping members. They also reduce or even eliminate the difficulty of connecting a machine to a tractor. These advantages result only when the equipment has been regularly lubricated — a maxim for all farm machinery. (Paper 95V)

CONVENIENT SHIELDING FOR PTO DRIVES — Power take-off drives are involved in 6% of the accidental farm equipment deaths. It is difficult to prevent the farmer from operating the equipment without the shielding because of the inconvenience of servicing and hooking up when the shielding is in place. The farm equipment industry has and should continue to accept the engineering challenge to provide adequate shielding which is also convenient to use.

A revised SAE-ASAE standard, to be published in 1960, provides that the shield on the PTO drive shall be integral with and journaled on the rotating members. The integral rotating-type shields are the only current American-made shield which qualify under this new standard. There are three European-made shields on the market which also qualify. (Paper 95W)

UNITING TRACTOR AND IMPLEMENT — The tractor and implement must be integrated by a hitch system which gives desirable operational characteristics to the combined units. The tractor serves as a powerplant to propel the operator and the implement, and to provide a source of hydraulic power for controlling this implement in working and transport positions. Operating advantages desirable in any hitch are:

1. Best possible compromise between maximum weight transfer and good implement penetration.

2. Constant, automatic and self-correcting means of depth control. This is accomplished through the geometry of the hitch which alters the pitch of the implement if it deviates from a pre-set level.

3. Flexibility which allows the tractor to move up and down with variations in terrain without disturbing the depth of implement. (Paper 96T)

FORD SEMI-MOUNTED PLOW — The semi-mounted plow frame is a hybrid between a mounted and pull-type plow. The specifications which guided the development of the Ford four-bottom semi-mounted plow are:

1. Must fit all tractors with three-point hitches with no tractor modifications.

2. Must be designed to provide easy coupling and simple operation.

3. Depth of plow must be controlled by the draft control system of the tractor, or have a gage wheel if no draft control system is available.

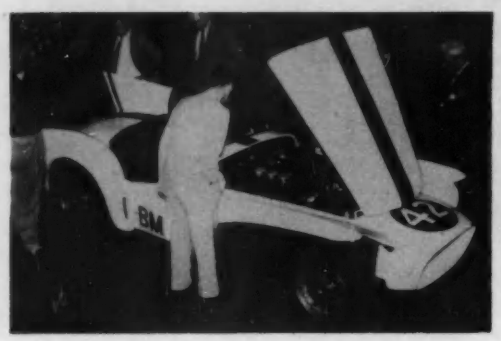
4. Must transport safely over rough and rolling ground and at high road speeds.

5. Must be available in frames up to

Continued on page 92

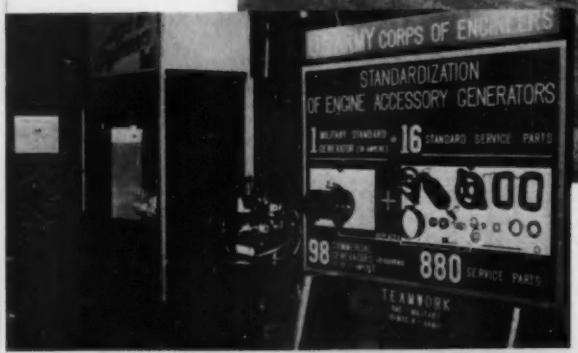
INSTRUMENTAL in the success of the FCIM Meeting was L. J. Lechtenberg, chairman, SAE Milwaukee Section.

C. W. OHLY (LEFT), R. A. Dimberg (center), and Anderson Ashburn discussing agenda of Production Activity Committee meeting. Ohly is meetings vice chairman of the Production Activity and Ashburn is vice president of the Activity. Dimberg was general chairman of the Production Forum.



BROOKS STEVENS of Brooks Stevens Associates had some of his antique cars on display at the Picnic.

Powerama Picnic — Spectacular



THE ARMY HAD ENGINES, engine accessories, and models of construction equipment on display.

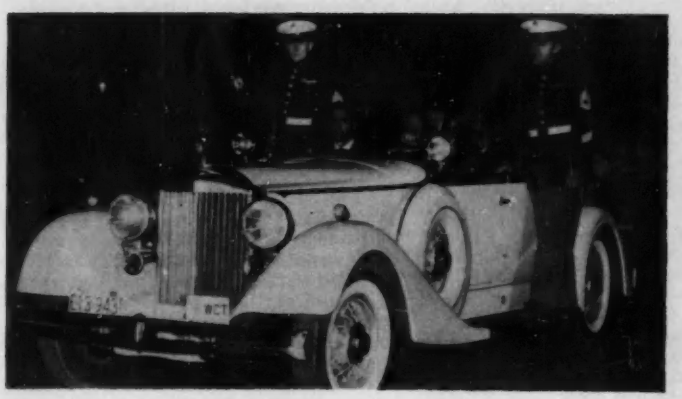
AIR FORCE DRILL TEAM provided snappy manual of arms to the enjoyment of the audience.

SAE PRESIDENT LEONARD RAYMOND (left) and W. G. Scholl, executive vice-president, Allis Chalmers Co. discussed the present and future of farm equipment for NBC monitor. The interview was heard nationwide.

COL. CHARLES A. STONE, USAF, poses with aircraft towing tractor — part of a USAF GSE display. Stone stressed the need for standardization and interchangeability in USAF equipment.

CARL SADLER, chairman, Aero-Space Council of the SAE Technical Board opened the ground support equipment phase of the Picnic Luncheon.

E. E. BRYANT, chairman, Luncheon Committee, welcomed the audience to the Powerama Picnic.



DIGNITARIES came to Picnic in 1934 Packard Dual Cowl Phaeton with Marine escort.

. . . and Engineering Display

FCIM Meeting

. . . continued from p. 89

four bottoms and take bottom sizes from 10 to 16 in.

6. Should make maximum use of existing production parts to simplify tooling and service parts problems. (Paper 96U)

CONTROL OF SEMI-INTEGRAL IMPLEMENTS — Weight transfer with limit, applied to semi-integral implements, increases the tractive efficiency of farm tractors and enables them to pull heavier and greater work-capacity implements. This results in greater utilization of engine torque as tractive effort, without an increase in static tractor weight.

The mounting has a single combination pull and load-sensing hitch point. Lift arms transfer weight to the tractor, but carry only a portion of the implement transport weight. The balance of the weight is carried by an implement transport wheel (or wheels) actuated by a remote ram mounted on the implement and controlled by automatic hydraulic valve. Limited vertical articulation is incorporated in the implement hitch of most long implements. (Paper 96V)

LINKAGE IS KEY TO HARROW FLEXIBILITY — With the advent of tractors with integral hydraulic lift systems, a new type of harrow construction has been developed — the frame of which not only pulls the harrow gangs through the soil but also lifts them for transport. The many variations currently produced all consist of a superstructure spanning the four gangs with the gangs held in place underneath. This superstructure is attached to the tractor lift links to form the harrow unit. In operation the whole structure is merely lowered into the ground for working or lifted free for transport. Working depth is controlled from the tractor by the lift links. (Paper 96W)

POSITIONING CONTROL OF FARM IMPLEMENTS — Positioning control of agricultural and construction implements is possible by use of a hydraulic servo mechanism. The position of the implement is precisely determined by the position of the control hand lever. The feed-back control through the push-pull cable makes accurate positioning possible. Any external loading tending to extend or contract the cylinder will trigger the valve at initial deflection of the implement and pump pressure will resist movement as in any conventional servo. By the addition of a simple override spring in the control linkage, it is possible to position the hand control rapidly, and to proceed with other operations while the desired position is being attained at the velocity permitted by the system flow rate. As soon as the desired position is reached, the valve shuts off and the cylinder piston remains stationary. (Paper 96X)

Production

APPLYING AUTOMATION UNDER TODAY'S OPERATING CONDITIONS — The "building block" concept in automatic machine transfer lines is growing — and the principle is working. For example, a Ford automated line tooled up to machine a 1958 V-8 engine block has been converted to perform the various operations required to machine an in-line 6-cyl engine for the 1960 Falcons. Another automated Ford line has been converted from 1958 V-8 heads to 6-cyl heads for the 1960 Falcon.

To answer the problem, "Should we automate?" you may find it helpful to ask this question, "How long will the product be continued without a major design change?" Back in the 1920's, A. O. Smith Corp. was producing an auto frame every 8 sec on an automated line. Auto frames stayed relatively unchanged for nearly 20 yr. Today, auto frames change so often the main assembly line at A. O. Smith Corp. is no longer automated.

But there are success stories from many automated installations. For example, in its oil pipe line plant, A. O. Smith Corp. reported labor charges represent only 2% of the sales dollar. This suggestion is offered: divide your products into those that are likely to change and those that won't change. Automation should be investigated thoroughly for the "won't change" jobs.

The case for including banks of parts in a production line should be considered. If banks for the lowest production machine are available, machines upstream can continue to operate as well as those downstream from a stoppage. A stoppage on a high production machine in the line is even less serious where banks are used.

HEAT TREATING TECHNIQUES — Much of the damage to machined work charged to the heat treat department may be due to careless handling of parts prior to the time they reach the heat treat. Careful stacking and racking of work is essential if rejects are to be held to a minimum.

Interest of heat treaters in high temperature carburizing is continuing. At the moment, it appears many heat treat shops may be holding back on this development, possibly as a means of getting stepped-up production should the need arise.

Most high temperature carburizing is in the 1800 F range but processing up to 2100 F has been reported.

Use of higher carburizing temperatures may result in a rapid rise in furnace deterioration. Very close temperature and atmosphere control is essential — although not easy to achieve. An increase of 50% in case depth has resulted from raising the furnace temperature from 1700 to 1800 F. An increase of 100% in case depth results from treatment at 1900 F. Grain growth is limited up to 1800 F but becomes much greater above this temperature where hypereutectoid carbides may form. These must be diffused to prevent embrittlement.

PRODUCTION PLANNING AND CONTROL FOR PROFIT, COST, AND SERVICE IMPROVEMENTS — The Heil Co. of Milwaukee has a unique method for controlling production so that all machines are loaded to maximum efficiency and investment in inventories is held to a minimum.

Under the Heil plan, central manufacturing is responsible for the production of parts which are fabricated by various divisions of the company. All parts to be produced are divided into "priority parts" and "shelf parts." Priorities are assigned by the management of the central manufacturing plant based on a study which showed that 50% of the parts were responsible for 95% of the production problems.

Priority parts are scheduled for production and equipment is assigned to these jobs. So-called shelf or standard parts are then scheduled to fill the production valleys on the various machines. This plan has resulted in more stable production by central manufacturing; it has also brought about a substantial reduction in inventory.

The "selective" approach to production planning is also being used to advantage by Carrier Corp. A study of parts requirements, for example, showed that 6% of the items accounted for almost 70% of inventory cost. Management, therefore, decided to break down its parts requirements into 3 classifications; high cost items, medium cost items, and low cost inventory. Inventory of the high cost items is selectively controlled so that excess inventories will not accumulate. On the other hand, low cost parts may be produced in lots sufficient for 6 months requirements without building excessive inventory.

Another interesting method of controlling production schedules is the use of a Telautograph system to tie-in inventory and dispatch of parts.

Under an earlier plan used by Carrier Corp., 15 expediters, working throughout the plant under a department foreman, were assigned to make sure that adequate supplies of parts would be delivered to each department. Their duties took expediters to many areas throughout the plant. Under the new system, the expediter stays in one department and sees to it that finished parts are moved along as rapidly as produced. Much confusion has been eliminated by the new system.

If your sales estimates are not as reliable as you would like them to be, you may wish to consider a plan used

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Secretary's reports of these panels will be available in full in multilith form in 6 to 8 weeks as SP-328. See order blank on page 6.

Panels

by International Harvester Co. Under this plan, all sales estimates are reviewed by an economic group that is divorced from sales. What is needed for more accurate sales estimates is a better foundation for making estimates. This means better sales records, better coding, and better informed people to make the final estimates.

The need for accurate sales and production forecasting is greater today than ever before. The speed with which technological changes are taking place make accurate forecasting a necessity.

ENGINEERING-PURCHASING RELATIONSHIPS — The engineering-purchasing relationship is not a dual relationship; there are invariably three parties involved — engineering, purchasing, and the vendor. It is important to keep all those involved in the development of a new product fully informed about any progress being made.

These rules are suggested for launching a new product successfully:

1. Eliminate false starts by avoiding setting up a relationship with a vendor who is unable to meet the requirements of the job.

2. Be sure all requirements of the job are spelled out in complete detail.

3. Keep your lines of communication open during the entire development program.

All interested parties should be brought in at the time a new program is started.

Then there is the question of payment of development costs of a new program involving a supplier. The concensus is that arrangements should be made with suppliers to pay compensation in many instances for costs directly incurred in the development of a new product. Payment may cover a small part or a large part of the development cost. There is no rule that applies in all cases. The important thing is to have an understanding at the time the program is started. This leaves the purchaser free to make his own decision about sources of supply for production parts.

WELDING METHODS AND PROCESS CONTROL — Opinion says that automatic welding will not replace manual welding for a great many production jobs. Where automatic welding reduces cost or improves quality, or both, automatic operation will be used; otherwise, manual welding will be continued.

Many factors must be considered in choosing welding equipment. Among a number of considerations, the number of parts and the weld quality desired are of paramount importance. Another factor influencing the choice of equipment is the cost of welding fixtures.

An interesting recent development is the extended use of CO_2 welding for the fabrication of farm equipment.

There should be more on-the-job training of operators. In addition to operator training, these considerations should be examined critically to achieve a reduction in welding costs: weld design; necessary welding quality; quantity of parts required; comparative cost of usable welding processes.

Iron powder electrodes are being widely used because of their high rate of metal deposition.

Welding engineers should be informed in advance of design changes wherever possible. It is also recommended that engineers be better informed about welding problems and welding procedures. Many engineers are surprisingly uninformed about welding.

COST SAVING IDEAS OR COST REDUCTION FOR SURVIVAL — The top requirement of a cost reduction program is the backing of top management. Without management support, the best cost cutting program is doomed to failure.

Even with management backing, the mortality rate of cost reduction programs is high. One out of three cost reduction programs will die within 3 yr. Sometimes, following a cost reduction program failure, the company is worse off than if the program had not been attempted.

Cost reduction programs may run head on into employee suggestion plans and it is strongly recommended that the basis for awards be clearly spelled out in any cost reduction program installed in a plant where an employee suggestion plan is in operation.

The conflict between the design engineer and the manufacturing engineer is inevitable and unavoidable. This explains the establishment of a growing number of Production Engineering Departments. The opinion has been expressed that design engineers may be losing considerable ground to production engineers in many metalworking plants.

What is the function of a cost reduction engineer? In its broadest sense, a cost reduction engineer is a man who is working with all his might to put himself out of a job!

A COMPLETE QUALITY CONTROL PROGRAM — The trend toward vendor rating is growing. But there are many problems. How can the necessary close relationships be established and maintained?

Use of a vendor rating program involves closer contact and more frequent contact between the vendor and the buyer. Performance by the vendor must be reviewed more often.

If vendor rating relationships can get over the initial hurdles and communications are kept open, this kind of setup may work out advantageously for both the buyer and the vendor.

Another debatable question is: should quality control belong to engineering or to manufacturing? The consensus usually is that quality control should be a part of manufacturing rather than engineering.

What type of personnel best fills the quality control job requirements? Should quality control managers be engineers or nontechnical personnel? An engineering background and a knowledge of machine operations is exceedingly helpful in arriving at the decisions a quality control manager is required to make.

PLANNING-ORGANIZING-CONTROLLING THE ADMINISTRATIVE FUNCTION — The importance of organization can hardly be minimized by a business hoping to survive in the face of keen competition. During an average month, 1250 U. S. business firms fail. Most of these failures can be attributed to failure to organize the business properly.

The technique of organizing for smooth, efficient operation may be compared to planning a military engagement. Both the tools to be used and the techniques for using these tools must be carefully chosen to fit the specific situation.

This suggestion is offered to those having responsibility for organizing a business: narrow your activities as much as possible; then pinpoint and delegate responsibilites to capable personnel in your organization.

Control is a perpetual problem with any business organization. The real problem, however, is: what degree of control should be exercised and how can this best be accomplished?

The importance of controlling engineering activities within the company is emphasized. Both input and output of the engineering staff needs to be carefully coordinated. Having established a staff and appointed capable supervision, responsibilities must be delegated properly to assure a smooth-running organization.

HOW TO PREPARE ENGINEERS FOR MANAGEMENT — Every manager should be responsible for the development of his men. And every man should be responsible for his own development. Engineers should be critical of any assignment which does not promote their development.

Some of the things that management can do to help engineers want to develop themselves are:

1. Establish a climate for self development — An educational leave policy has merit. Promote advanced research and give recognition to progress in research — both financial and promotional.

2. Give the engineer a concrete definition of what is expected of him.

3. Performance appraisal — This should be primarily a self appraisal.

4. Optimum use of outside training (educational) and internal (on-the-job) training.

5. Manpower planning — Make optimum use of development in the engineer.

Missile bases on the moon, operating costs of cargo planes—and the World Series—were a few of the topics discussed at the

Los Angeles Aeronautic Meeting

TALK of missile bases on the moon, comparative prestige of U. S. and Russian scientists, and lowering operating costs of cargo planes was interspersed with conversation about the World Series at the fall SAE National Aeronautic Meeting, held in Los Angeles, October 5–9. Nontheless, the World Series (which was concurrent with the meeting) didn't seem to affect the number of persons going to the meeting — 2800 registered — or their interest in the many events scheduled during the week. These events included:

- Aircraft Manufacturing Forum
- 19 sessions for the presentation of papers
- a panel discussion on Communication between Vendor and prime contractor
- two luncheons, one featuring R. L. Johnson of Douglas and the other Dr. Joseph Kaplan of California Institute of Technology
- Student Engineers' Night
- a dinner-dance in the Cocoanut Grove
- meetings of the Aerospace Council and other SAE Technical Committees and committees of the joint SAE-API Coordinating Research Council
- meetings of the SAE Aircraft Powerplant and Aircraft Activity Committees and their Subcommittee on Reliability, and the Air Transport Activity Committee
- SAE Missiles and Aircraft Engineering Display

Dr. William Ballhaus of Nortronics was chairman of the Planning Committee for the Meeting program. The Production Forum, of which Kenneth G. Farrar of Douglas was sponsor, was arranged by a special committee under the chairmanship of A. W. Morgan of Convair.

At the luncheon on Tuesday, October 6, R. L. Johnson, who is chief engineer of Douglas' Missiles and Space Systems Division pointed out the advantages of having missile bases on the moon: (1) They would be a deterrent to nuclear attack on a nation possessing such lunar bases because they would insure retaliation. (2) They would obviate need for dispersal or mobility of earthbound missile bases.

Because of the value of lunar bases, we may find ourselves not only seeking to develop equipment for such bases but also for defending them or attacking those of an enemy. A war fought on our satellite for control of lunar bases instead of on our planet would benefit mankind by removing the blast of atomic weapons from our atmosphere.

A lunar base faced with an alarm of attack would have ample time to make sure the alarm was triggered by a weapon — and not by a defect in the warning system — and to defend itself, Johnson said.

He predicted space transports as big as his company's DC-8's but he warned that these space transports would require new orders of reliability designed and built into them.

Speaking at the luncheon on Thursday, October 8, Dr. Kaplan pointed out that, as a result of the projects carried out in connection with the International Geophysi-

PRODUCTION FORUM Chairman A. W. Morgan and Sponsor K. G. Farrar admire the mounted certificates of appreciation for outstanding service to the Society presented to them by Anderson Ashburn, SAE vice-president for the SAE Production Activity, for their work on the Forum.

WRIGHT BROTHERS MEDALLIST Kermit Van Every (center) of Douglas and his wife chat with J. T. Dyment, chairman of the Wright Brothers Board of Award. Van Every received the gold medal and certificate at the luncheon on Thursday for his 1958 paper on high-speed aerodynamics.

LUNCHEON SPEAKER R. L. Johnson (right) astounds Toastmaster J. H. Famme with a preview of the ideas he aired in his talk on lunar missile bases and military operations in their support.

SECTION CHAIRMAN C. F. Thomas of Southern California Section dines with Major Gen. T. A. Bennett, USAF, and other attendees at one of the Meeting's two luncheons held in the Cocoanut Grove room of the Ambassador.

FOUR TOP EXECUTIVES meet informally: T. V. Jones of Northrop, Donald Douglas, Jr. of Douglas, Lee Atwood of North American, and W. F. Ballhaus of Nortronics.

DR. WILLIAM F. BALLHAUS, chairman of the Planning Committee for the Meeting received SAE's thank-you plaque from Frank W. Fink.

EYE-CATCHING SIGNS helped entice attendees away from televised World Series games and into rooms where the 12 Production Forum panels were held — not that much enticement was needed. Experts on the panels were kept busy answering questions from their audiences. Chairmen had difficulty in closing off discussion when time allotments came to their end, and several panels played to SRO crowds.

cal Year, scientific capability has become a major factor in international prestige.

He noted too that the engineer and the scientist are enjoying new recognition from their non-technical brethren, although perhaps not so much in this country as in Russia. When a Russian is elected to the Soviet Academy of Science, he gets a raise equivalent to about $500 per month, plus a country home. An American elected to the U. S. National Academy of Sciences is assessed $10 dues per year. But comparing his lot with that of a Russian scientist, Kaplan, who is a member of the U. S. Academy, said "He can have it!"

The 150 students who attended Student Engineers' Night toured the Display, then heard talks by four of the industry's leading engineers. J. B. Wassall of Lockheed explained that SAE welcomes students to its Meetings because it feels a responsibility to supplement their classroom instruction with exposure to the thinking and practices of engineers in industry.

D. E. Walters of Lockheed, speaking on career opportunities in the air transport field, told students that one of the problems for their generation is to design air cargo systems that will bring ton-mile costs down from the present 18¢ per ton-mile to the 3.5¢ per ton-mile offered by trucks.

Maxwell W. Hunter of Douglas Aircraft's missiles and space engineering department predicted extensive military operations in space. "With tomorrow's powerful warheads, that will be the only place left to detonate them," he said.

William F. Ballhaus of Nortronics urged students to (1) Get a good training in the fundamentals of mathematics, physics, and chemistry. (2) Steer a middle course between specializing and generalizing at the start of their careers. (3) Cultivate the attitude that things *can* be done — and do them.

While commercial presentations were, as always, proscribed from the Meeting's sessions, companies were afforded a chance to present their products and facilities in the Engineering Display. Eighty of them took advantage of the opportunity, filling the 120 booths available and pleading for more. Most attendees spent almost as much time inspecting the exhibits and talking with the technical experts manning them as they did listening to presentations in sessions.

Throughout the Production Forum sessions and the other sessions and in committee meetings ran talk of reliability.

In the Production Forum's Handling panel, for example, experts pointed out how good materials-handling techniques contribute to the reliability of electronic equipment. An example cited was corrosion failures found in electronic equipment in service. Investigation disclosed that assemblers tended to push the chassis along the surface of wooden work benches. Friction removed the anticorrosion coating which was applied to the chassis. The solution was to mount the chassis in a fixture which could take the wear and tear on the work bench and preserve the coating.

In a panel discussion on the achievement of product reliability, stress was put on the fact that you can't achieve reliability by putting on a short-term campaign and then forgetting about it. There must be a continuing effort to achieve reliability.

Reliability starts with the engineering department — which can, no doubt, make or break the product's reliability record — but responsibility for reliability must extend throughout the whole company organization, it was emphasized.

To insured reliability of a liquid hydrogen system in a missile, the designer should assume that there will be a leak in every joint sooner or later and design so that such a leak will not be a reliability and safety hazard. Designers were reminded that hydrogen gas leading through an oriface creates a static electrical charge. Also hydrogen, unlike most expanding fluids, heats up as it expands through an oriface.

Hydrogen leading into the open air is easier to safeguard. The main hazard is that hydrogen will burn readily in air once it is ignited. Although hydrogen gas isn't visible and a hydrogen flame is sometimes hard to see, burning around joints can be detected readily if the joints are wrapped with tape. The tape will burn with a noticeable flame and will leave a charred residue which is a tip-off that hydrogen is leaking.

The procedures for handling liquid oxygen safely are generally sufficient for the safe handling of liquid hydrogen — but for different reasons. In training workers to handle liquid hydrogen, it isn't enough to refer them to procedures for handling liquid oxygen. They should be trained in the reasons why these procedures work for liquid hydrogen. This goes for design engineers, assembly workers, test stand personnel, and all other employees who can affect the performance of the liquid hydrogen system.

A quick tour of other Production Forum panels produced these ideas:

— There is a trend toward leav-

EAST PRAISES WEST. SAE Vice-President Anderson Ashburn of New York tells men responsible for Production Forum that it was the "best yet." Ashburn spoke at the "afterglow" following the final Forum sessions, at which the Forum committee and panel leaders met to exchange ideas on how to make next Forum still better.

PANEL LEADER W. J. Cecka says he and his panel members enjoyed their stint.

ing production information off drawings. Reason is that it costs less to make changes. Engineers from several companies mentioned that nondestructive testing information is no longer being specified on their companies' drawings.

— Plastic vessels lined with rubber can retain helium for hours at 3000–4000 psi. Voids in the walls of these plastic vessels cause trouble. One way to check for the presence of voids is to weigh the vessel.

— Major General T. A. Bennett, who was a member of the panel on Missile Support Equipment, remarked that he was glad to find SAE taking an interest in the less glamorous side of missile weapon systems, the support equipment. Industry's engineers working through SAE can make great strides toward providing workable, economically feasible systems. The Air Force, he expects, will always have to have a field and depot maintenance system.

— Even the experts haven't yet solved the problem of handling 0.006-in. thick skins.

— The way to put operations research techniques to work in a plant is to hire one recognized OR man as leader who can talk intelligently with people in the organization who will be a source for problems, and who can assemble a a group of specialists in various fields to make up the OR teams. In recruiting specialists, the leader must be in a position to assure recruits that the results of their OR studies will be used and that the problems will be interesting.

The advice given in the Production Forum and elsewhere during the Meeting on achieving reliability can be summed up this way: In the drafting-room stage, each drawing should be reviewed to evaluate it from the reliability viewpoint and to correct details contributing to unreliability. On the production floor, supervisors must take steps to develop their workers' pride in craftsmanship. Just giving orders isn't enough. The supervisor must tell the worker exactly what to do, tell him why the task is to be done that way, let the worker know when he is performing the task properly, and give him recognition when he does perform it properly.

Other ideas gleaned from the 57 papers presented at the Meeting follow.

RELIABLE GSE FOR HOUND DOG — GAM-77, or Hound Dog, a turbojet air-to-surface missile capable of being launched from the B-52, is a high-performance system. So it requires the support of highly reliable ground equipment. The missile's flight control system is tested by a flight attitude positioner capable of displacing the entire assembly of missile and attaching pylon in pitch, roll, and yaw planes. The positioner is operated by a control console, controlled by the automatic checkout control console. (Paper 97T)

LIQUID OXYGEN INTENSIFIES THOR GSE PROBLEMS — Thor, an intermediate range ballistic missile with a range of 1500 miles, is propelled by RP-1 fuel and liquid oxygen cryogenic propellant. The use of liquid oxygen created problems, such as trailer design. Fresh air pulled into the heaters and coolers of the trailers could not be contaminated by the liquid oxygen vapor boil-off because of the fire hazard. So tall vent pipes higher than the danger level of boil-off from the missile were added. (Paper 97U)

FACTORIAL ANALYSIS OPTIMIZES FALCON GSE — Hughes Aircraft has developed a system of "factorial analysis" for making efficient trade-offs in the design of ground support equipment. This method of analysis, as used for the Falcon air-to-air missile, involves assignment of factors for such considerations as ease of operation, adaptability, personnel requirements, and combat readiness for each element of the various possible ground support systems under analysis. Cost and weight are also figured in. The factors are then added together, and the possible systems are compared on the basis of their respective grand totals. (Paper 97V)

ABLATION MATERIALS EVALUATED FOR HIGH TEMPERATURES — Ablation testing showed some interesting results . . . such as the effect of post-curing treatment observed with quartz fiber-reinforced phenolic. The long-time, low-temperature post-curing provided a material which ablated at a much slower rate and to a lesser degree than the short-time, higher-temperature post-cure. This large improvement indicates the sensitivity of reinforced plastics to material preparation variables and to possible avenues of materials research. (Paper 98T)

EXTRUDING DEVELOPMENT PROGRAM FOR PURE BERYLLIUM AND HIGH-TEMPERATURE STEEL — Results of a program on extrusion of a T-section from high-temperature steel has shown that A-286 steel can be extruded at 2100 F to a thickness of 0.093 in. The best temperature for A-286 is 2050 F; for H-11 it is 2250 F. A concurrent program on extrusion of bare beryllium has proved that it is feasible. Future process refinements are ex-

pected to make aircraft-quality beryllium extrusions available in popular sizes, shapes and lengths within two years. (Paper 98U)

COMMON MATERIALS CAN BE USED IN ROCKET ENGINES — Stringent requirements can be met with relatively common materials by good design and careful manufacturing techniques. The most challenging application of materials in high temperature service is in the turbine which drives the propellant pumping system. It has been possible to upgrade the power rating of the entire turbine assembly by 50% over its original design rating by the following: (1) more stringent quality control requirements on both the investment cast blade and the complete assembly, and (2) by incorporating the design-improvement of the interlocking shroud blade on first- and second-stage turbine wheels in combination with material chosen for its metallurgical properties. (Paper 98V)

STRUCTURAL FOIL FOR HOT PARTS — MiniWate is an all-spot-welded, foil-gage, structural material for use at elevated temperatures. It is a single-skin, corrugation-stiffened structure with strength equivalent to that of double-skin brazed sandwich of equivalent weight. The structure eliminates blind spot welds, simplifies inspection, and reduces manufacturing costs. (Paper 99T)

OPTIMUM JOINT DESIGN FOR HIGH-TEMPERATURE HONEYCOMB PANELS — There are two basic approaches — pictorial and analytic. Pictorial is a useful tool for comparative screening through instinct and judgment. The analytic approach attempts to synthesize a joint from a series of efficient configurations known to have certain load-carrying abilities. The analyst considers the loads in terms of hardware details which he then attempts to combine into an integral, producible structure. Regardless of approach, producibility is major factor in final selection. (Paper 99U)

STEEL SANDWICH IS MASS PRODUCED — North American Aviation has developed a production process and machines for fabricating Spacemetal sandwich. The sandwich is resistance welded steel with a corrugated core and two facing sheets. The equipment consists of two major pieces: a 5-in., 65-row core machine and a 30-in., 385-row welder. Costs of Spacemetal structures are favorable compared with conventional material construction, and provide large savings compared with customized fabrication. (Paper 99V)

VIBRATION ISOLATION ON NON-RIGID SUPPORTING STRUCTURES — A procedure has been established for the dynamical design of linear vibration isolators to protect rigid equipment from sinusoidal motions of a non-rigid supporting structure. A single degree of translational freedom of the equipment is assumed. Three types of data are required: (1) equipment mass and its so-called fragility curve, (2) mechanical admittance of the supporting structure and its amplitude of vibration when it supports no load, and (3) information to establish a minimum stiffness of the isolators. There are methods to estimate source admittance, free source velocity, and equipment fragility when measured data are not available. The design procedure yields a region of permissible-natural-frequency and fraction-of-critical-damping combinations for the isolator-mass system. The specification for the isolator dynamical requirements, including allowable tolerances, is derived from this region. (Papers 100T and 100W)

TRENDS IN SYSTEM DAMPING — Experimental and analytical knowledge on the major sources of inherent structural damping — hysteresis in structural materials, interface slip, and interface adhesive shear — has made its application to structural design practicable. However, interface slip must be used with caution, because of the fretting and corrosion it may produce. Relative importance of hysteresis in the structural materials and interface adhesive shear depends on the configuration, how it is optimized, and the force regimes considered. However, most structural materials are selected and shaped for properties other than large damping, while the interface adhesive may be especially selected and the layer thickness optimized for large damping. So interface adhesive shear can contribute greatly to total damping in such an optimized design. (Paper 100U)

PRINCIPLES OF SHOCK AND VIBRATION TESTING — A test program is adequate if: (1) It reaches the preset objectives within reasonable limits of tolerance; (2) It mobilizes not more than the essential of manpower, equipment, processing time, and evaluation; (3) It uses reasonably balanced power, bandwidth, detection threshold, and processing accuracy levels, compatible with the test objectives; and (4) It does not pretend to conclude more than what is physically contained in the test results. (Paper 100V)

MAKE SHOCK AND VIBRATION TESTS MORE REALISTIC — Shock and vibration tests are usually established on the basis of maximum intensities of shock and vibration that occur in the field, and for locations at which equipment to be tested may be used. If the equipment is not negligibly light compared with the foundation on which it is mounted, this procedure leads to overconservative and difficult-to-perform tests. Simpler and more suitable tests result if the impedance of the mounting platform is as great as the field mounting foundation, and no compensation made for dips in the excition spectra. (Paper 100X)

DAMPED STRUCTURES INCREASE LIFE OF HIGH-SPEED-AIRCRAFT EQUIPMENT — Highly damped structures which utilizes viscoelastic damping materials appear to be a very promising method of controlling resonant amplifications in electronic equipment. Structural damping techniques can be used to successfully reduce the acceleration transmitted to critical electronic components. In many cases, this reduction in transmitted vibration makes the difference between acceptable and unsatisfactory equipment design. Also, a component having a given fragility level rating can be used in a vibration environment that would normally prohibit its use due to amplification of vibration by the conventional structure. (Paper 100Y)

VIBRATION ISOLATION SYSTEM IS ALMOST RESONANCE-FREE — The "dynamic isolation system" is an almost resonance-free vibration isolation system for use where regular mounting systems are not adequate. It is constructed by extending the damped-dynamic vibration-absorber theory. Many applications in the missile field today require mounting systerms with resonant frequencies at 40 cps or higher. When the environment is on the order of 15 g's, even a transmissibility of 2 can be too much for the electronic equipment. But a transmissibility of 1.5 would change certain failure to success. These are the cases where the dynamic isolation system may be useful. (Paper 100Z)

PROGRESS REPORT OF SAE SUBCOMMITTEE ON RELIABILITLY — The Subcommittee, which reports to SAE's Aircraft and Aircraft Powerplant Activity Committees, is confining its efforts primarily to the mechanical aspects of aircraft and missiles. One of the most important and urgent areas of its activity will be a manual for the guidance of the designer and others. A working group for this purpose has been established and has started this project. (Paper 101T)

SNARK FUEL SYSTEM DESIGNED FOR RELIABILITY — Simplified system design was the greatest single factor for attainment of reliability in the SM-62A Snark missile fuel system. When the Snark was redesigned, the following changes were among those made: (1) Absolute mechanical simplicity with no electrical functions was achieved in the design of the series phase c.g. control of the fuel system. (2) Eliminated components were flow proportioner, inertia valves, level control valves, precheck solenoids, float switches, gate valves, shut-off valves, pressure regulators, and relief valves. (Paper 101U)

DESIGNING FOR RELIABILITY — Environment-strength separation factors in the past have been selected by trial and error methods which have resulted in limiting the number of failures to a satisfactory level. However, there are better procedures for selecting environment-strength separation factors. In order to minimize probability of failure, the procedure should be to separate individual strengths from environments with an unreliability cri-

terion. In this approach, reliability (or unreliability) values are assigned to each element of a system, with a further breakdown into each of the possible element failure types. (Paper 101V)

600 F AIRBORNE ELECTRICAL SYSTEM IS FEASIBLE — The USAF has initiated a program to develop by 1962 a 600 F airborne electrical generation and distribution system. Based on work done to date, there is little doubt that such a system is feasible. But major development work is still needed in some areas, such as semiconductor rectifiers and 1000 F flexible moisture-resistant insulation. Solutions are currently available for these in the 600 F region, but are marginal. The basic 115/200 v, 400-cps three-phase a-c system is built around a 40-kva generator, with all other components operating from this system. Two constant speed drives are being developed under this program. Sundstrand has selected a hydrostatic system with a mechanical differential feature. Lycoming has been developing a mechanical traction drive with success. (Papers 102T, 102U, and 102V)

CFR COKER AND FLIGHT EVALUATIONS OF FUEL THERMAL STABILITY — Thermal stability measurements are related to the amount of deposits formed on heating fuel in a jet aircraft and in the engine prior to and during the time it is burned. The CFR Fuel Coker pass-fail test clearly distinguishes stable fuels. The performance of JP-5 fuel found thermally stable at 300 F preheater and 500 F filter temperatures has been satisfactory in Navy service with no deposition difficulties in the engine fuel systems. (Paper 103T)

FUTURE APPLICATIONS OF DUCTED FAN POWERPLANTS — There are three main applications for the ducted fan engine in the future — (1) subsonic logistic and transport aircraft, (2) vertical take-off aircraft, and (3) supersonic transport aircraft. The most important present application of the ducted fan engine is subsonic logistic and transport aircraft because it is superior to the turboprop for high subsonic cruise, and superior to the turbojet in the areas of take-off thrust, cruise fuel consumption, noise level, and specific weight. In the future, higher bypass ratios will be used for those cases requiring the highest ratio of take-off thrust to cruise thrust. (Paper 103V)

PRATT & WHITNEY'S "SMALL" TURBOJET ENGINE — THE JT12 — Pratt & Whitney's 3000-lb thrust turbojet, the JT12, has just completed an unofficial 150-hr qualification test only 16 months after the first engine run. Prior to this, it also: (1) demonstrated altitude fuel consumption, (2) was successfully flight tested in April, (3) operated to customer satisfaction after on-time delivery of prototypes, and (4) completed the official 50-hr pre-flight rating test. Weighing 436 lb, the engine has a two-stage turbine, 7:1 design pressure ratio, and nine compressor stages. (Paper 103U)

MACHINE TESTS HIGH-TEMPERATURE MATERIALS FOR FLIGHT VEHICLES — In order to test alloys used in present and near future vehicle design, Marquardt developed an elevated temperature testing machine. It was specifically developed to test materials in tension, compression, and creep or any combination at any desired temperature level. Using this equipment, complete documentation of a number of advanced alloys has been possible at elevated temperatures of 200–3500 F. The equipment has the ability to test an alloy of magnesium at 200 F — immediately followed by a molybdenum alloy specimen at 3500 F with no change in the test setup. (Paper 104T)

DESIGN OF HOT AIRFRAMES WITH CURRENT MATERIALS — Structures for hot airframes may be designed to avoid the complexities of artificial cooling systems and attach-

SUBCOMMITTEE on the Right Approach to Reliability held its third meeting and laid plans for a projected reliability manual for designers. F. D. Applegate (white shirt) is chairman.

JOHN LOWRY (right) of NASA demonstrates to SAE Vice-President G. W. Gilmer a model of a kite-like structure which might be used to reduce landing speeds of supersonic transports. Kite is aluminum-coated plastic film.

SAE COMMITTEE A-9 met during the Aeronautic Meeting. Among decisions made was to change its name to Aerospace Environmental Control Systems Committee (from Aircraft Air Conditioning Equipment Committee).

NEWSREEL CAMERAMAN got closeup of Navy pilot modeling early type of pressurized high-altitude crew suit.

DISPLAY of SAE publications and membership-promotion material informed nonmembers about the advantages of joining the Society.

SPEAKERS at Student Engineers' Night were W. F. Ballhaus, J. B. Wassall, D. E. Walters, and M. W. Hunter.

PREPRINT COUNTER sold 3008 copies of papers, including a few in a new format now being sales-tested at Meetings.

PRESS ROOM served the 50 reporters on hand to cover the Meeting. J. B. Edwards was publicity chairman for the Meeting.

ing insulating materials for thermal protection. This is achieved by properly arranging suitable high temperature materials, and minimizing thermal stresses where possible. Material cooling through radiation is a practical means of lowering structural temperatures. High surface emissivity is desirable even though it aggravates thermal gradient problems. (Paper 104U)

TALON STRUCTURAL COMPONENTS USE INVESTMENT CASTINGS — The T-38 Talon supersonic jet trainer uses investment castings of 17-4PH steel (for all intents and purposes identical to AMS 5355) as prime structural components. Major problem with these castings has been low ductility which was due to microshrinkage and to dendritic ferrite. It was found that retarding the cooling rate of the mold minimizes microshrinkage, reduces ferrite content, and reshapes the ferrite into a globular and blocky form. (Paper 104V)

METHODS FOR ANALYSIS OF COLD PLATE CONDITIONING SYSTEMS — Two methods are proposed, each using a lumped network approach. The matrix method is more suitable for steady-state analysis. The network equations are arranged in matrix form, and lump temperatures found by matrix inversion. The thermal analyzer method is recommended for transit problems. Initial temperatures are specified for each lump and succeeding temperatures are found by solution of the heat balance equation for each lump separately. (Paper 105T)

MEETING FLIGHT VEHICLE POWER REQUIREMENTS — Solar energy shows increasing promise as the best way to meet long-duration flight power requirements for the period of 1965–70. In the power range of 5–30 kw, solar dynamic systems are expected to be optimum. They may even give nuclear devices stiff competition up to 100 kw. There are, however, corrosion and erosion problems. Solar energy collectors and heat radiators also require improvements. (Paper 105U)

HIGH-TEMPERATURE THERMOCOUPLE MATERIALS ARE COMING — Better alloys for high-temperature thermocouples are being developed. The ultimate temperature measurement capacity of alloys operating unprotected in an oxidizing atmosphere will be about 1800 C. They will be platinum metals containing minor additions. Beyond 1800 F it will be necessary to rely on temperature measurement devices based on other principles — such as microwave attenuation. (Paper 105V)

MINIMIZING MISSILE STRUCTURAL WEIGHT AND COST — Increase of missile performance, and the attendant increase of mass ratio, requires the reduction of per cent structural weight to prevent the all-up missile weight from becoming excessive. Reinforced plastic external structure appears promising for high-perform-

ance missiles designed for short flight periods. Brazed and welded sandwich should be considered when quality is assured and cost lowered. (Paper 106U)

PROPERTIES OF ASBESTOS-REINFORCED PLASTIC LAMINATES — Erosion and ablation resistance, and strength at high temperatures of asbestos-reinforced plastic laminates were tested in simulated rocket environments. Both phenolic and silicone resins — reinforced by long-fibered chrysotile asbestos — were tested. Although these materials were found unsatisfactory for very-high-temperature rocket engine conditions, phenolic asbestos showed possibilities as nose cone material. And, silicone asbestos appeared feasible for rocket bodies or structural components that would be subjected to 800 F for long periods of time. (Paper 106V)

HOW RADIATION AFFECTS AIRCRAFT MATERIALS — Irradiation of most materials used in aircraft can cause transient or permanent effects. For example, the permanent damage to organic solids can take the following forms: (1) increase followed by decrease in tensile strength, (2) decrease in elongation, (3) embrittlement, (4) increase in compression set, (5) decrease in peel strength, and (6) decrease in dielectric strength. (Paper 107T)

NUTATING-DISC MOTOR SUITED TO PNEUMATIC ACTUATORS — An air motor based on the nutating-disc principle is promising for use in a high temperature pneumatic actuation system. The nutating disc is attached to a central sphere and mounted in an annular chamber which has a spherical sidewall bounded by conical upper and lower surfaces. Absence of complex valving in this nonexpansion positive displacement motor assures high reliability. It gives high performance and high efficiency throughout a wide range of inlet pressures, temperatures, speeds, and loads. Also offered is rapid reverse operation and high frequency response. (Paper 107U)

CONVAIR 880 FUEL SYSTEM RELIABILITY BEING DEMONSTRATED — Full-scale fuel system test stands are being used for the major portion of the 880 demonstration tests before first flight. The program consists of these test phases: small-scale model, full-scale test stand, icing and low-temperature stand, fuel quantity gaging system calibration, and individual fuel system component. This program is augmented by whatever flight testing is required. (Paper 107V)

FATIGUE ANALYSIS APPLIED TO AIRCRAFT FASTENERS — Titanium alloy fasteners and their counterparts in steel were axial-tension fatigue tested in a variety of sizes, types, and configurations. In the majority of comparative fatigue tests, the titanium parts were stronger at all load levels tested. New developments in dynamic fastener tests include acoustic fatigue, shake, and various combinations normally expected in ballistic missile or boost glide vehicle designs. (Paper 108T)

B-58 CYCLIC FATIGUE CERTIFICATION PROGRAM — The general objectives of this program are: (1) To locate any areas of the B-58 airframe which might fail from fatigue during its expected service life so that these areas may be redesigned promptly. This will be accomplished by cyclic fatigue testing various components and one complete airframe. (2) To provide a basis for analytical prediction of the service life expectancy of the airframe for the plane's various uses. Program consists of six major phases: (a) development of load spectra, (b) preparation of fatigue analyses, (c) development of test load spectra, (e) fatigue tests of components, and (f) flight data gathering programs. (Paper 108U)

ESTIMATING AND PRESERVING TURBINE TRANSPORT STRUCTURAL LIFE — Estimating time to the start of fatigue damage requires predicting the probable load environment, and the probable fatigue response of the proposed structure to that environment. Working tools like the Palmgren-Miner cumulative damage rule, and the available statistical load data are ways of establishing fatigue performance level. The success to which structure realizes the potential fatigue performance is a function of actual structure and actual cumulative load experience. Maximum utilization of a given fatigue potential is possible by control of environmental load experiences. Coupled with fail-safe structures, inspection and maintenance procedures can safely extend actual service life beyond expected or even unexpected first appearances of fatigue damage. (Paper 108V)

WING GUST FATIGUE DAMAGE PREDICTED BY NEW METHOD — Aircraft wing gust fatigue damage can be predicted by power spectral analysis and constant life fatigue curves. Power spectral analysis predicts aircraft wing experience in terms of oscillatory bending moment. Fatigue characteristics are represented by constant life curves. Superposed gust damage is evaluated by determining the S-N curve for a constant mean stress from the representative life curves. (Paper 108W)

JET PROBLEMS AT NY INTERNATIONAL AIRPORT — The jet poses new problems to the airport operator arising principally from noise, jet blast, aircraft size, and type of fuel. The Port Authority requires that critical noise level be set at 112 PNdb. Every time a new plane is built, the airport operator has to: (1) lengthen (and sometimes strengthen) runways; (2) provide more apron space: (3) enlarge hangars. (Paper 109T)

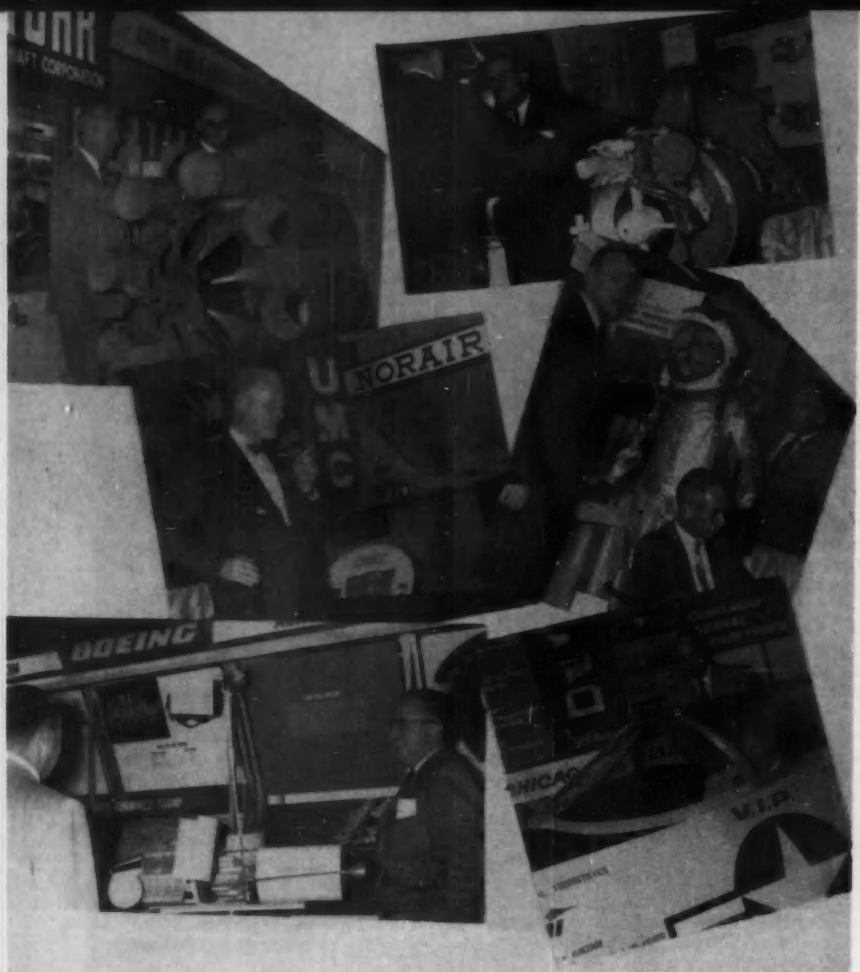
TWA GROUND SUPPORT FOR JETS — Among TWA's current development programs is a preloaded baggage and cargo handling system which promises to be efficient and economical. New passenger loading equipment is also being developed. — TWA is now testing a ground level ramp in Kansas City. (Paper 109U)

SYSTEMS APPROACH DECREASES COSTS OF JET AIRCRAFT SUPPORT — This approach applies the principles of engineering, economics, logistics, marketing, and operations analysis to control the operation of complex airborne vehicles. It has been applied to the two primary operations of jet aircraft support as follows: (1) Maintenance — the approach has been to integrate installation, removal, handling, transportation, repair and testing of components so that they can be executed with minimum support equipment. (2) Ground movement — the approach in this area has been to develop a method of ground movement which would safely provide speeds equivalent to those of taxiing. It must also supply the aircraft with adequate auxiliary power without depending on main jet engines. (Paper 109V)

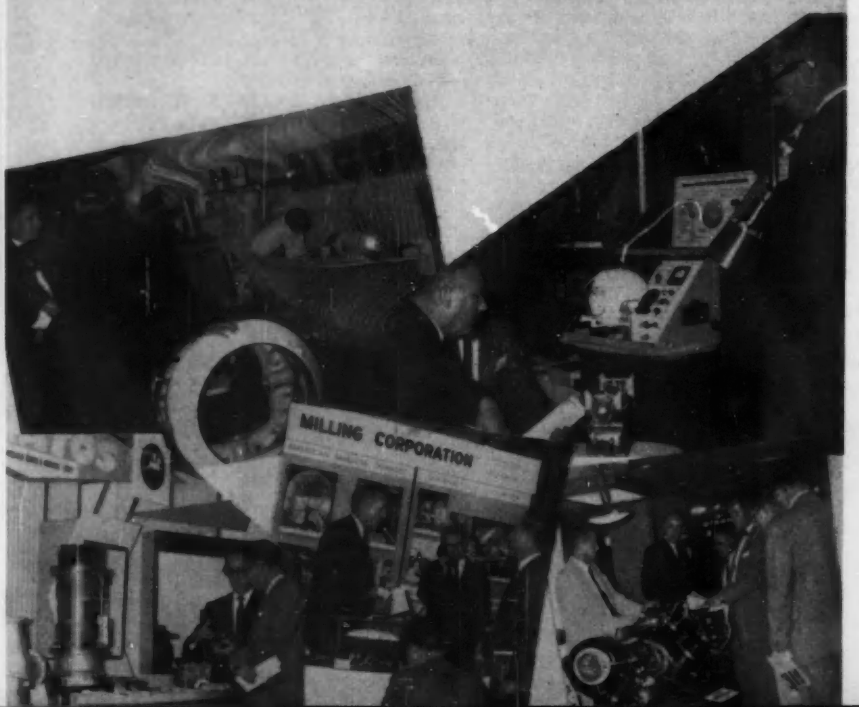
MINOR OPERATING DIFFICULTIES OF BOEING 707 BEING CORRECTED — Boeing 707 service problems are conventional and capable of straight-forward solution. Causes of mechanical troubles have been pinpointed and beneficial corrective action taken. System difficulties such as hydraulic leaks, poorly performing air conditioning, and submerged pump in water injection system, are also being corrected, and are on the downward trend. (Paper 110T)

AMERICAN AIRLINES REVIEWS ITS FIRST JET YEAR — The two airplanes American has introduced into service are behaving quite differently. The Electra is fairly well devoid of operational problems — while the 707 has had many problems. After American's

PANEL on communication between vendor and prime contractor met for lunch just before its presentation. R. G. Sharp (right foreground) was panel chairman. Sharp has a much bigger job ahead: he has been named chairman of the Planning Committee for the October 1960 SAE National Aeronautic Meeting.



sae missiles & aircraft engineering display



Boeing 707-123 was converted to turbofan, there was improvement in take-off runway length required, range-payload, and community noise level. (Paper 110V)

DESIGN OF A MACH 3 TRANSPORT — Wing structure may be rigidity-critical, in which case the configuration will aim toward the maximum rigidity-weight ratio. The fuselage, on the other hand, may be strength-critical, and for this case stiffened skin construction using titanium material becomes very attractive. (Paper 111T)

AUTOMATIC INERTIAL NAVIGATION FOR SUPERSONIC TRANSPORTS — Present-day, production-line, automatic inertial navigation equipment offers today's air transport industry a self-contained navigational system capable of rendering aircraft completely independent of all ground-based installations except the terminal airports. It also is a means of supplying continuously and automatically exceedingly precise positional reports. (Paper 111U)

DOPPLER-INERTIAL SYSTEM IS ACCURATE — Doppler-inertial outputs meet the stringent requirements for flight control in a high-performance aircraft. The system provides aircraft attitude, ground velocity, present position, distance to destination, and distance to the left or right of desired ground track. All of these quantities are measured or computed continuously and are instantaneously available and accurate. (Paper 111V)

MATERIAL PROPERTIES AFFECT 1000 F MOTOR OUTPUT — At 1000 F, suitable insulations are now limited to refractory materials — brittle, with low expansion coefficients, high moisture absorption, and low elongation. Until someone formulates a mica or ceramic elastomer, 1000 F insulation is bound to be thick and have a low effective dielectric breakdown characteristic. Because of this greater thickness, winding space factor becomes relatively low. Small space factor decreases specific output of a motor. The combination of thinner insulation and larger wire size can greatly improve space factor. (Paper 112T)

RESULTS OF HIGH-TEMPERATURE BEARING PROGRAM — A program to develop 2–7 in. bore, self-aligning, 800–1500 F antifriction bearings capable of accommodating radial loads up to 130,000 lb, revealed the following: (1) For 800 F unlubricated roller bearings, in short life high unit load applications, high speed tool steel of M-2 classification heat-treated to a Rockwell "C" hardness of 61–63 was adequate. (2) Titanium carbide of Rockwell "C" hardness 65–69 (room temperature) has strong possibilities for 1500 F unlubricated roller bearings. (3) As many bearing components as practical should be fabricated from the same material to avoid thermal expansion problems within the bearing itself. (Paper 112U)

SAE NEWS

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Council Set To Judge

by **George A. Delaney,** chairman
Committee on Interpretation of
the Society's Constitutional Areas of Operation

BORDERLINE ACTIVITIES are of doubtful value to the Society and its members. This conclusion reiterates itself year after year as SAE Council and Section Governing Boards face decisions as to whether a proposed activity is proper for the Society, its Sections, or its committees.

Most seriously proposed activities are clearly within or without the Society's Constitutional areas of operation. But some *are* borderline. And because borderline projects are generally agreed to be of doubtful value, Council set up a special committee to recommend practical criteria by which decisions could be made on such cases. (It was designated "Committee on Interpretation of the Society's Constitutional Areas of Operation.")

One thing the special committee agreed about promptly. "Should such a borderline activity be undertaken, it should be done with an awareness that it *is* borderline and definitely questionable and should be re-examined periodically to justify its continuance."

The Committee saw eye to eye also on several other basic considerations:

1. The fact that an activity is for a good purpose is, in itself, insufficient reason for SAE to participate.
2. The fact that "everyone else is doing it" may not mean it is right for SAE. (SAE's Constitution is more definite than those of some other technical societies. What may be entirely correct for another Society may not be within the scope of SAE, as defined by the Constitution.)

The Committee's recent recommendations to SAE Council grew from its agreement on these general principles. They consisted of two parts:

(1) An amendment to the By-Laws, and (2) criteria by which individual proposals might be judged.

The amendment to the By-Laws — finally approved by Council (which next year will be known as the Board of Directors) at its Sept. 13 meeting — emphasized:

a. That the Society's principal efforts shall be concentrated on furthering its objectives through "holding meetings for the presentation and discussion of papers, development of technical reports . . . and the publication and distribution of same."

b. That, in other areas permitted by the Constitution, efforts should be limited to technical area activities "which contribute to individual member service and enhance the value of Society membership to the individual member."

c. That proposed activities not specifically covered in rules and regulations of the Engineering Activity Board, the Sections Board, the Technical Board or other committees or local units "must be referred to the Board of Directors."

d. That the Directors may establish general criteria to guide the Society groups in judging these borderline cases.

Then the Committee recommended certain specific criteria of the kind which the Directors might wish to establish as permitted in the new By-Law.

As a basis for these specific criteria, the Committee spelled out first the objectives of the Society and the principal means for their accomplishment as stated in the SAE Constitution.

They showed that:

Paragraph C 2 sets forth the general objective.

> C 2. The object of the Society is to promote the Arts, Sciences, Standards, and Engineering Practices connected with the design, construction and utilization of self-propelled mechanisms, prime movers, components thereof, and related equipment.

Paragraph C 3 spells out the principal means to be used in attaining this objective.

> C 3. The principal means for accomplishing this object shall be the holding of meetings for the presentation and discussion of professional papers, the development of technical reports including engineering standards and recommended practices, and the publication and distribution of same.

In paragraph C 2, the objective is purposely phrased in general terms to permit flexibility in meeting member needs in an era of advancing technology. The Society is incorporated under the laws of the State of New York and the Constitution is a legal document defining its permissible areas of operation under these statutes. It is desirable that the areas so defined be sufficiently broad so that future technical developments may be adequately served.

Then the Committee's recommendations went on to present the following Guides to some of the areas in which these general objectives *may* be pursued within the basic philosophy of the SAE Constitution, as follows:

Stimulating Members to Make Greater Contributions to SAE.

Everything which encourages members to participate in meetings, committees, the administrative bodies, and all other Society sponsored activities contribute to this objective.

Bringing Members Greater Satisfaction from Participating in SAE.

Participation is a two way street and within itself creates satisfaction. Greater satisfaction can be achieved if participation also increases technical knowledge. The Production Forums are examples of activities which stimulate members to make greater contributions to SAE and, in return, bring greater satisfactions through the technical information developed.

Rewarding Accomplishment in SAE.

The certificates and plaques awarded by many of the boards and committees are examples of means for attaining this objective.

Adding Prestige, Dignity, and Strength to SAE (or any SAE group.)

Those elements which enhance the reputation of an individual or an organization are the objectives sought in this particular Guide.

Gaining Friends for SAE (via public relations or otherwise).

SAE is justly proud of its accomplishments over the last fifty years and of its present stature in the technical areas which it serves. Bringing these accomplishments and aspirations to the attention of our friends and neighbors both in industry and among the public will enhance the value of Society membership to the individual member.

Gaining Members for SAE.

The continuing existence and vitality of this organization must reside in its ability to attract new members. Dignified activities to promote membership are a continuing objective of the Society. The membership committees, both national and Section, lead in this activity.

BORDERLINE ACTIVITIES

For Practical Application . . .

To facilitate practical application to individual proposals of principles outlined in this article, the Committee on Interpretation of the Society's Constitutional Areas of Operation has made available the following three guide-checklists.

These guide-checklists detail the points to be considered in making a decision in the case of any specific borderline proposal.

THE PRINCIPAL CONSTITUTIONAL MEANS

The principal means for accomplishing the object of the Society shall be the holding of meetings for the presentation and discussion of professional papers, the development of technical reports including engineering standards and recommended practices, and the publication and distribution of same.

The purpose of these principal objectives has been expressed as: —

The development, collecton and distribution of technical information in all areas of member interest.

To what degree does the proposed activity CONTRIBUTE TO: —

- The DEVELOPMENT of technical information
- The COLLECTION of technical information
- The DISTRIBUTION of technical information
  - (a) in MEETINGS
  - (b) in PUBLICATIONS

THE GENERAL CONSTITUTIONAL OBJECTIVE

"The object of the Society is to promote the Arts, Sciences, Standards and Engineering Practices *connected with the design, construction, and utilization of self-propelled mechanisms, prime movers, components thereof, and related equipment.*"

..... efforts of the Society shall be limited to those activities in its technical areas which contribute to individual member service and enhance the value of Society membership to the individual member.

To what degree does the proposed activity CONTRIBUTE TO: —

- Stimulating Members to Make Greater Contributions to SAE
- Bringing Members Greater Satisfactions from Participation in SAE
- Rewarding Accomplishment in SAE
- Adding Prestige, Dignity, and Strength to SAE (or any SAE group)
- Gaining Friends for SAE (via public relations or other means)
- Gaining Members for SAE
- Improving Membership Standards in SAE

OTHER VITAL CONSIDERATIONS

All activities of the Society involve the expenditure of time and money.

The best interests of the Society will be served when these assets are used in the most efficient manner.

What effect does the activity in question HAVE ON: —

- Member Service or Satisfaction per Dollar of Funds Expended
- Member Service or Satisfaction per Hour of Time Expended
- Funds derived from Journal Advertising
- Funds derived from SAE Exhibits
- Funds from Industry for SAE Cooperative Engineering Programs

'59 Springer Award to Warren M. Wiese

Warren H. Wiese

"IF YOU SQUEEZE THEM, MUST THEY SCREAM?" is the paper that won for Warren M. Wiese the 1959 Russell S. Springer Award . . . presented annually to the youngest SAE member whose paper is published in SAE Transactions during the year.

Presentation of the award was made on Oct. 12 at SAE's Detroit Section meeting in the Rackham Educational Memorial.

The paper deals with some of the factors contributing to rumble, knock, and surface ignition which plague today's high compression engines. It was originally presented at SAE's 1958 Summer Meeting and appears in 1959 Transactions (pp. 175–183).

Wiese, born in Rochester, Minn., received a BS in Mechanical Engineering in 1950 and an MS in 1952 from the University of Minnesota. He joined General Motors Research Staff in 1952 as junior engineer, and is currently senior research engineer in charge of road tests in the Research Staff's Fuels and Lubricants Dept.

Amendment to SAE By-Laws

AT its September meeting, the SAE Council approved an addition to the Society's By-Laws that defines the Society's general areas of operation.

The new paragraphs, developed by the Committee on Interpretation of the Society's Constitutional Areas of Operation, provide that proposed activities not specifically covered in Rules and Regulations of various Boards, committees and local units must be referred to the Board of Directors; and authorize the Board of Directors to establish general criteria to guide the Boards, committees and local units in judging whether proposed activities are in accord with those principles the Board considers in the best interests of the Society.

Following is the By-Law, as approved by Council, to become effective at the beginning of the 1960 administrative year, at the same time as the amended Constitution:

> The principal efforts of the Society shall be concentrated in the areas set forth in paragraph C 3 of the Constitution.
>
> In the other areas permitted under C 2 of the Constitution efforts of the Society shall be limited to those activities in its technical areas which contribute to individual member service and enhance the value of Society membership to the individual member.
>
> Proposed activities not specifically covered in Rules and Regulations of the Boards, committees, and local units must be referred by them to the Board of Directors.
>
> The Board of Directors may establish general criteria to guide the Boards, committees, and local units in judging whether such activities are in accord with those principles the Board considers in the best interests of the Society.

You'll

. . . be interested to know . . .

RULES AND REGULATIONS for the new SAE Engineering Activity Board were adopted by this Board at its September 12 meeting in Chicago. Adoption came after several hours of thoughtful debate on each of the 10 Sections, the first of which — as finally decided upon — defines EAB's objective in the following two paragraphs:

"The objective of the Engineering Activity Board is to develop, collect, and distribute technical information of value to members of the Society in the areas of the Society's engineering interests.

"It shall also be the objective of the Engineering Activity Board to provide, through engineering activity committees, opportunity for active participation by the maximum number of members, thereby enhancing the value of Society membership."

WHERE THEIR FELLOW-MEMBERS STAND TO GAIN — SAE members do the job.

For instance:

Farm, Construction and Industrial Machinery Activity and Milwaukee Section members took care of an SAE booth at the National Farm, Construction and Industrial Machinery Meeting in Milwaukee in September. Members of Body, Engineering Materials, Passenger Car and Production Activities helped man the membership table at the National Automobile Week meeting in Detroit last March. At the April National Aeronautic Meeting in New York, members again volunteered for a similar job.

And then there were the 20 SAE members — mostly from Fuels and Lubricants Activity — who volunteered to man SAE's booth at the Fifth World Petroleum Congress in June in New York. . . . ALL 20 SHOWED UP.

IMPORTANT SUPPORT of 1960's Membership Committee program will come from subcommittees representing SAE's three main arms — the Sections, Engineering, and Technical Boards . . . according to the report presented at the Membership Committee's Executive Committee at its September meeting. Planned also are subcommittees representing specialized areas-of-inter-

est — such as industry executives, educators, etc. The program and subcommittee personnel is expected to be formed at Annual Meeting in January.

VIRGIL SIMONICK, assistant chief design engineer, Douglas Aircraft Co., has been appointed alternate to Paul T. Vickers, SAE's representative on the American Conference Committee of the 1961 International Heat Transfer Conference.

The Conference will be held in the United States Aug. 28 to Sept. 1, 1961 at the campus of the University of Colorado at Boulder. It will be under the joint sponsorship of the American Society of Mechanical Engineers, American Institute of Chemical Engineers, Institution of Mechanical Engineers (Great Britain). SAE will participate along with the American Chemical Society, American Nuclear Society, American Rocket Society, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Chemical Institute of Canada, the Engineering Institute of Canada, and the Institute of Aeronautical Sciences.

The purpose of the Conference is "to make known new fundamental knowledge and practical developments in the field of heat transfer and to bring together persons engaged in research, development, and application for discussion and exchange of information." It is the second such conference, the first having been held in London in September, 1951.

FOUR SAE-NOMINATED DIRECTORS on Coordinating Research Council — to serve for two years starting Jan. 1 — are: H. F. Barr, chief engineer, Chevrolet Motor Div., GMC; G. J. Huebner, Jr., Chrysler's executive engineer for research; C. A. Lindblom, IHC's asst. to vice-president for engineering; and C. C. Ross, Aerojet-General's vice-president for engineering.

Already Directors, and with one more year to serve, are M. R. Bennett, IHC's manager of engineering; V. G. Raviolo, Ford's special asst. to vice-president for engineering and research; and H. W. Zipp, Boeing's asst. to senior vice-president.

DR. MICHAEL FERENCE, JR., Ford's Scientific Laboratories executive director, is the new chairman of SAE's Science-Engineering Advisory Committee. Dr. L. R. Hafstad, who has been chairman ever since organization of this Committee in 1957, will remain as a committeeman.

D. B. ALBRECHT, senior engineer, Standard Oil (Ohio), and **THEODORE McGILL**, New York City's director of safety, have been added to the Transportation and Maintenance Activity Committee.

D. B. HAMMOND, Willys Motors' vice-president for engineering, has been appointed a member of the Tech-

SAE NATIONAL MEETINGS

- **January 11–15**
  Annual Meeting (including engineering display), Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

- **March 15–17**
  National Automobile Meeting, The Sheraton-Cadillac, Detroit, Mich.

- **March 22–24**
  National Production Meeting, Statler Hotel, Cleveland, Ohio

- **April 5–8**
  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.

- **June 5–10**
  Summer Meeting, Edgewater Beach Hotel, Chicago, Ill.

- **August 16–19**
  National West Coast Meeting, Jack Tar Hotel, San Francisco, Calif.

- **September 12–15**
  National Farm, Construction and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 10–14**
  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 25–27**
  National Transportation Meeting, Hotel Leamington, Minneapolis, Minn.

- **October 31–November 1**
  National Diesel Engine Meeting, Hotel Cleveland, Cleveland, Ohio

- **November 3–4**
  National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

nical Board for a term which will expire Dec. 31, 1961. He will serve for the unexpired term of G. W. Mork, who has resigned.

"IF IT MOVES ON THE GROUND, THROUGH THE AIR, OR INTO OUTER SPACE, it's the concern of SAE," Student-Gram Editor K. W. Gordon contends. Pointing in this direction is the poster (shown here) for college bulletin boards and for display at Student Branch meetings.

JAMES A. MILLER, Minneapolis-Moline's director of engineering, is a new member of the Tractor and Farm Machinery Activity Committee.

"OPERATION SAE HANDBOOKS" is what E. P. White's Student Committee calls its current endeavor to get old Handbooks channeled into Student Branches and Groups. White says: "Last year's copy — even the one for the year before that — is still valuable to the students . . . so, let's get them out to the boys." He suggests the Student Committee chairman in each Section as a good channel through which to get the old Handbooks to students.

"FACULTY OPPORTUNITIES in SAE" is a special study subject for Student Committeeman A. W. Denny. Ideas targeted for all interested faculty people are expected to result.

FACTS

. . . from SAE literature

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.)

HOW SAE SERVES THE PRODUCTION ENGINEER is the theme of the Membership Committee's new booklet titled "For Production Men Who Want to Grow."

★

"THE OBJECT OF THE SOCIETY" is to promote the Arts, Sciences, Standards and Engineering Practices connected with the design, construction and utilization of self-propelled mechanisms, prime movers, components thereof, and related equipment."

This is paragraph C 2 as it appears in the new edition of SAE's "Constitution and By-Laws" which was mailed to the entire membership recently.

Letters from Readers

From:
Clifford Sklarek (M '29)
Los Angeles 28, Calif.

Dear Editor:

The monotype body and square engine of the single cylinder automobile I built in 1905 (see photograph below) seems to be the modern thinking of today's automobile manufacturers . . . but at the time I built the car, I was too young to exploit my ideas.

My car would do about 18 mph and easily outran a factory-built 2-stroke Elmore. I used it on the roads around Canton, Ill., where I lived at the time and, after about a year, I got the urge for a little more style and comfort — an urge I have regretted to this very day. So, I sold it to a farmer and bought a brand-new factory-built Buick Model F. Then I plunged into the auto business to make my living.

I didn't follow today's hot-rodding practice of modifying existing components . . . . I went whole hog into new construction.

I built the entire engine myself. It was a 1-cyl, 4-stroke unit, water-cooled with a thermo-syphon cooling system. It was a side-winder, with crankshaft positioned crosswise in the body and a fixed crank for starting.

It had a mechanical exhaust valve and an automatic suction intake valve, popular in those days. The timing gears and timer were outside the crankcase and I used a buzzer spark coil with jump spark ignition inserted in the top of the cylinder head. The square engine — $3\frac{1}{2} \times 3\frac{1}{2}$ in. — was built soundly enough to turn 2000 rpm. I had a countershaft mounted in the center of the chassis, which carried two free-running cone clutches facing each other. On each clutch was mounted a sprocket lined up with two sprockets on the crankshaft. This gave me both a low and a high gear.

The shifting of the clutches was by a sort of tiller lever, so that the shift lever was in my lap. I was thus able to go to either first or second gear by sliding the cones, fastened to the countershaft on long keyed slots. There was no reverse.

I built a wheel steering device and had the throttle and spark levers on the steering post, in approved fashion.

The carburetor was a plain suction tapered valve mixing device with gasoline coming in on the bevel of the valve through a small drilled hole. It was fed to the engine by suction of the valve lifting off the seat. The carburetor did not have a float and mixture was made each time the engine was started by adjusting a needle valve.

From:
P. Brownell and A. Fredrickson
Fram Corp.
Providence, R. I.

Dear Editor:

We would like to point out that some of the statements in the article, "Turbine Fuel Filtration," by G. T. Coker, H. R. Heiple, and R. G. Davies (SAE Journal, June, pp. 52–53) are misleading.

The point is made that pleated pa-

continued on page 134

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

Cass and Benner Join Automotive Council

Cass

Benner

Former SAE President **ROBERT CASS** and **PAUL B. BENNER** have joined the Technical Board's Automotive Council at the behest of Council Chairman George Huebner, Jr. The scope of the engineering experience they bring to the Council is broad.

Robert Cass, who was SAE President in 1953, is assistant to the president of White Motor Co., a firm with which he has been associated for 34 years. During this time he has kept in touch with European motor transport and engine development through repeated travel. Before World War II, business took him to Russia twice and to China once.

In Washington during the Korean War, Cass was director of the Motor Vehicle Division of the National Production Authority. He is now a member of the President's National Defense Executive Reserve.

An Englishman by birth, Cass came to the United States as an instructor in engineering at Harvard University in 1924.

Paul Benner is chief engineer of Caterpillar Tractor's Decatur Plant. As such, he is responsible for the development and design of motor graders and wheel tractors. A graduate of Iowa State College, he has been designing earthmoving and road building equipment for most of his 24-year Caterpillar association.

SAE-wise, Benner was 1958 chairman of the Construction and Industrial Machinery Technical Committee of which he is still a member. He has also been a member of the Tractor and Farm Machinery Activity Committee, serving as Meetings Vice-Chairman in 1956.

AT ITS FIRST MEETING since the Technical Board reorganization the Aero-Space Equipment Division of the Aero-Space Council directed some 46 groups under its jurisdiction to encourage participation of the missiles industry. On hand to congratulate in-coming Equipment Division Chairman P. H. Jones (standing fifth from left) at a Chicago meeting in September was his predecessor Aero-Space Council Chairman Carl Sadler (extreme left). Standing from left are: Carl Sadler, Sundstrand Aviation; R. H. Davies, Parker-Hannifin Corp.; D. L. Cauble, Sundstrand Aviation; C. P. Steele, Boeing Airplane Co.; P. H. Jones, North American Aviation; E. N. Cunningham, Precision Rubber Products Corp.; G. R. Keller, Autonetics; A. H. Hobelmann, Walter Kidde and Co.; and H. H. Borneman, Lear-Pomec Division. Front row: B. D. Brandon, Chance Vought Aircraft; D. S. Deskey, SAE Staff; and B. F. Jones, B. F. Goodrich Co.

General Materials Council Sponsors

THE three most heavily used sections of the SAE Handbook cover ferrous, nonferrous, and nonmetallic materials, according to an SAE-conducted survey of 1959 Handbook subscribers.

A breakdown of 500 replies shows:
75% use ferrous metals reports
68% nonferrous metals reports
65% nonmetallic materials reports

Under the new Technical Board structure, the General Materials Council sponsors over 100 materials reports which make up these Handbook sections. Thus, the Council reviews all *new, revised,* and *reaffirmed* reports emanating from the four ground vehicle technical committees assigned to it by the Technical Board three months ago. The committees include the Iron and Steel Technical Committee, Nonferrous Metals Committee, Nonmetallic Materials Committee, and Fuels and Lubricants Technical Committee.

Materials experts have been selected to serve with **Council Chairman M. L. Frey,** assistant to general works manager at Allis-Chalmer's Tractor Division. They include **C. M. Heinen,** assistant chief engineer, Materials, Chrysler Corp.; **J. G. Moxey, Jr.,** assistant director, Research and Development Department, Sun Oil So.; **C. F. Nixon,** head, Electro-Chemistry Dept., Research Labs., General Motors Corp., **J. T. O'Reilly,** supervisor Materials and Equipment Engineering Dept., Ford Motor Co.; **Dr. E. S. Rowland,** chief metallurgical engineer, Timken Roller Bearing Co.; and **Dr. E. C. Smith,** chief metallurgist and director of Research, Republic Steel Corp.

A rundown on recent events in the ISTC's 33 Divisions reveals the following.

Ferrous Materials at Elevated Temperatures — A newcomer to the ISTC is Division 35 on Properties of Ferrous Materials at Elevated Temperatures. This group is developing information on:

- Classification of high temperature ferrous materials.
- Methods of evaluating high temperature properties of ferrous materials.
- How to select ferrous materials for specific high temperature applications.
- Listing of tests useful in the selection of appropriate ferrous materials.
- General information on production procedures.

Low Temperature Properties of Ferrous Materials — Issuance of a completely revamped SAE Information Report on Low Temperature Properties of Ferrous Materials results from a two-year program of extensive research. This Division 24 report is now available as TR 169.

Check on Shot and Grit Sizes — A more realistic check on shot and grit sizes is behind the revision of SAE's Recommended Practice on Cast Shot and Grit for Peening and Cleaning. Its tables now provide for *cumulative percentages* of shot and grit allowed when different size screens are used during quality analysis. The revised Division 20 report will appear in the 1960 Handbook.

Machinability Ratings for Alloy Steels and Castings — Along with its work on machinability ratings for carbon steels, Division 11 is working on ratings for alloy steels and castings.

Valve Steels — A uniform test procedure for checking valve steels is being sought by Division 15. When completed, the report will contain information on chemical and mechanical properties.

Prestressing Metals — Mechanical prestressing of metals is the subject of a proposed SAE manual under development by Division 20. Surface rolling and related mechanical prestressing treatments will be covered.

Titanium and Titanium Alloys — Preparation of an extensive revision to existing SAE information on titanium has been assigned to the Miscellaneous Alloys Subcommittee of the Nonferrous Metals Committee. The possibility of developing SAE grade designations for titanium and titanium alloys is also being considered.

Electroplating — A special Nonferrous Metals Committee subcommittee

continued on page 112

This is the last . . .
in a series of four stories on the four new Councils of the SAE Technical Board. The Board's reorganization is described in full on pages 106 and 107 of the July issue.

SEVEN materials experts form the General Materials Council. Their prime responsibility is to guide the work of four major SAE technical committees. These include the Iron and Steel Technical Committee, Nonferrous Metals Committee, Nonmetallic Materials Committee, and Fuels and Lubricants Technical Committee.

Heading the Council is **MUIR L. FREY,** assistant to the general works manager at Allis-Chalmer's Tractor Division. Prior to joining Allis-Chalmers 14 years ago, he was chief metallurgist at Packard Motor Car's Aircraft Engine Division, John Deere Tractor Co., and Gerlinger Electric Steel Casting Co.

A member of the Technical Board, Frey is chairman of the Board's Publication Policy Committee. In 1957, he was SAE Vice President of Engineering Materials. He has been a participant in Iron and Steel Technical Committee work for many years.

CHARLES M. HEINEN is assistant chief engineer for materials at Chrysler Corp. At the age of 18, his career at Chrysler began by working as a laboratory assistant by day and a Walter P. Chrysler Scholar by night. He graduated from the Chrysler Institute of Engineering with a mechanical engineering degree in 1938. Later, he received a B.S. and a M.S. in chemical engineering at the U. of Michigan.

Prior to becoming supervisor in the Gas Laboratory (where he worked on

Heinen

Most Used Parts of Handbook

an A-bomb project for two years), Heinen worked in Chrysler's chemistry, electroplating, and physical testing laboratories. In 1950, he became supervisor of the Fuels and Lubricants Laboratory.

Heinen is chairman of the Fuels and Lubricants Technical Committee, a position he has held since 1956.

JOHN G. MOXEY, JR. is assistant director of Sun Oil Company's Research and Development Division. His work there began 24 years ago shortly after receiving a mechanical engineering degree from Swarthmore College.

The 1952 SAE Vice President for Fuels and Lubricants, Moxey was chairman of the Horning Memorial Award Committee last year. He has been very active in the work of the Coordinating Research Council, and is currently a member of the Technical Board and Publication Policy Committee.

CLEVELAND F. NIXON heads General Motor's Electro-Chemistry Department. As such he is responsible for research and development of adhesives, elastomers, plastics, and electroplating. Before assuming this position in 1952, he was director of the Process Development Section of GM's Ternstedt Division.

Nixon is chairman of the Nonferrous Metals Committee as well as 1959 SAE Vice President for Engineering Materials. He has been on the Engineering Materials Activity Committee since 1953, serving as meeting vice-chairman in 1957 and 1958.

JAMES T. O'REILLY is supervisor of the Materials and Equipment Engineering Department of Ford's Manufacturing Engineering Office. In recent years he has been working with nonmetallic materials and processes. During World War II, he was responsible for rubber and plastics control and development at the Willow Run B-24 Liberator Bomber Plant.

O'Reilly is chairman of the Nonmetallic Materials Committee and past chairman of the SAE-ASTM Technical Committee on Automotive Rubber.

DR. E. S. ROWLAND is chief metallurgical engineer at Timken Roller Bearing Co. His career began in 1933 as an instructor at Pennsylvania State University. Two years later he joined Timken where his time was primarily devoted to research and development of steel and bearings. He assumed his present position in 1952.

The 1959 chairman of the Iron and Steel Technical Committee, Dr. Rowland is exceptionally conversant on standardization needs and practices. He is also chairman of the ISTC's active Division 4 on Residual Stresses.

DR. EARLE C. SMITH is chief metallurgist and director of research at Republic Steel Corp.

A former instructor at Ohio State University, his graduate work in mineralogy and metallograph at Ohio State took him to the Gary Works of U. S. Steel where he worked as a third helper on the open hearths.

During World War I he was a trouble shooter in Pittsburgh at steel and forge plants for the Aircraft Production Group. Afterwards, he became chief inspector of Central Steel which mergered with United Alloy Steel. He subsequently became assistant general superintendent and assistant district manager of Republic's Central Alloy District.

A current member of the Technical Board, Dr. Smith has long been active in ISTC affairs, serving as chairman of several ISTC groups.

Chairman Frey

Moxey

Nixon

O'Reilly

Rowland

Smith

General Materials Council

. . . continued

is developing a new approach to electroplating specifications based on determining plate durability by means of accelerated tests rather than thickness measurements.

Wrought Aluminum — The possibility of developing data on anodized aluminum for an SAE Handbook report is being investigated by the Wrought Aluminum Subcommittee. This would supplement the already extensive information available in the Handbook on various forms of wrought aluminum.

Nonmetallic Materials

Central Hydraulic Fluids — Performance requirements for central hydraulic fluids (used in passenger cars) are being devised and coordinated by two Council groups. Under consideration are two fluid types: One a petroleum base; the other a synthetic.

Both the Central Hydraulic Power Fluid Subcommittee of the Nonmetallic Materials Committee and Subcommittee H on Power Assist Fluids of the Fuels and Lubricants Technical Committee expect the proposed SAE Recommended Practice to be issued as an interim TR prior to its inclusion in the 1961 Handbook.

Motor Fuel Characteristics — To provide automotive engineers with information on the more pertinent characteristics of motor fuels, the Fuels and Lubricants Technical Committee formulated an SAE Information Report on Motor Fuels. The report provides an overall concept of the significant properties of automotive gasolines, and tells where the standard test methods needed to define or evaluate these properties may be found. It will be included in the 1960 Handbook.

Synthetic Foams — Specifications and tests for cellular products containing interconnecting cells made of polyvinyl chloride or copolymers are given in a new SAE Recommended Practice. Flexible Foams Made from Polymers or Copolymers of Vinyl Chloride (15 R) describes seven test methods: Indentation load deflection, compression deflection, air over aging, compression set under constant deflection, static fatigue, dynamic flexing, and density.

The report was adopted by the Nonmetallic Materials Committee after its formation by the SAE-ASTM Technical Committee on Automotive Rubber.

Synthetic Resin Plastic Sealers — Specifications and test methods for automotive-body-type sealers are given in a new SAE Recommended Practice, Synthetic Resin Plastic Sealers, Non-Drying Type. This report is applicable to the nondrying, nonbleeding, and noncorrosive sealers that can be extruded to a specified size and used as a medium for producing a water tight seal between two pressed steel sections or between rubber and steel.

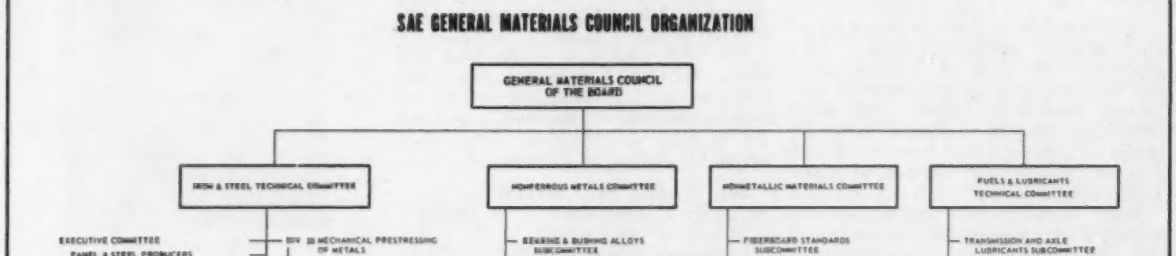
Technishorts . . .

T. H. SPENCER, quality control manager of Caterpillar Tractor's Peoria Plant, will be 1960 chairman of the Iron and Steel Technical Committee's Panel D — Tractor and Earthmoving Equipment. He succeeds J. D. Graham, chief engineer of International Harvester's Materials Engineering and Engine Standards.

At a recent Milwaukee meeting, Panel D urged the SAE-AISI Task Group on Carbon Steel Hardenability to continue evaluating data for carbon steel hardenability bands. It also recommended to ISTC Executive Committee that the development of decarburization limits be studied.

A. M. HANSEN, Chrysler Corp., has been appointed chairman of SAE's Reinforced Plastics Subcommittee by Nonmetallic Materials Committee Chairman J. T. O'Reilly. He succeeds J. G. Coffin of Chevrolet's Engineering Center. At present, the Subcommittee is developing an SAE Information Report intended to guide automotive engineers in their selection and use of reinforced plastic materials.

RATING AGRICULTURAL POWER UNITS — A test code for agricultural power units is being studied by the Tractor Test Code Subcommittee. At a fall meeting in Milwaukee, the Tractor Technical Committee instructed the Subcommittee to continue to coordinate its work in this area with the Nebraska Tractor Test Board.


SAE GENERAL MATERIALS COUNCIL ORGANIZATION
GENERAL MATERIALS COUNCIL OF THE BOARD
IRON & STEEL TECHNICAL COMMITTEE
NONFERROUS METALS COMMITTEE
NONMETALLIC MATERIALS COMMITTEE
FUELS & LUBRICANTS TECHNICAL COMMITTEE
EXECUTIVE COMMITTEE
PANEL A STEEL PRODUCERS
PANEL B CASTINGS
PANEL C AUTOMOTIVE
PANEL D TRACTOR & EARTHMOVING
DIV. 1 EDITORIAL
DIV. 2 TEST PROCEDURES
DIV. 6 METAL JOINING MATERIALS*
DIV. 7 CARBON STEELS
DIV. 9 AUTOMOTIVE IRON CASTINGS
SECTION A GRAY IRON
SECTION B MALLEABLE IRON
SECTION C MODULAR IRON
DIV. 10 AUTOMOTIVE STEEL CASTINGS
DIV. 11 MACHINABILITY
DIV. 12 DEFINITIONS OF HEAT-TREATING TERMS
DIV. 13 HIGH STRENGTH, LOW ALLOY STEELS
DIV. 14 ALLOY STEELS
DIV. 15 WROUGHT CORROSION RESISTANT STEELS
DIV. 16 STEEL HARDNESS CONVERSION NUMBERS
DIV. 18 BEARING STEELS
DIV. 22 MECHANICAL PRESTRESSING OF METALS
CHEMICAL & PHYSICAL PROPERTIES OF SHOT
COVERAGE
SURFACE ROLLING
TEST STRIP STANDARD
DIV. 21 HEAT & CORROSION RESISTANT ALLOY CASTINGS
DIV. 23 FUNDAMENTALS OF CASTING DESIGN
DIV. 24 LOW TEMPERATURE PROPERTIES OF FERROUS MATERIALS
DIV. 25 NON-DESTRUCTIVE TEST METHODS
DIV. 27 PREVENTION OF CORROSION OF IRON & STEEL
DIV. 28 TOOL & DIE STEELS
DIV. 29 PHYSICAL REQUIREMENTS FOR THREADED FASTENERS
DIV. 30 (A) BEAM DEPTH
DIV. 30 (B) DECARBURIZATION
DIV. 32 CARBON SHEET & STRIP STEEL
DIV. 33 GEAR METALLURGY
DIV. 35 CARBIDE CUTTING TOOLS
DIV. 36 PROPERTIES OF FERRITIC MATERIALS AT ELEVATED TEMPERATURES
DIV. ON CARBON STEEL HARDENABILITY BANDS
BEARING & BUSHING ALLOYS SUBCOMMITTEE
CAST ALUMINUM ALLOYS SUBCOMMITTEE
CAST & WROUGHT MAGNESIUM SUBCOMMITTEE
COPPER & COPPER-BASE ALLOYS SUBCOMMITTEE
METAL JOINING MATERIALS SUBCOMMITTEE
MISCELLANEOUS ALLOYS SUBCOMMITTEE
WROUGHT ALUMINUM SUBCOMMITTEE
ELECTROPLATING SUBCOMMITTEE
POWDERED METAL ALLOYS SUBCOMMITTEE
FIBERGLASS STANDARDS SUBCOMMITTEE
HYDRAULIC BRAKE FLUIDS SUBCOMMITTEE
ENGINE COOLANTS SUBCOMMITTEE
UPHOLSTERING MATERIALS SUBCOMMITTEE
ORGANIC COATINGS SUBCOMMITTEE
REINFORCED PLASTICS SUBCOMMITTEE
SEALERS, ADHESIVES AND SEALERS SUBCOMMITTEE
CENTRAL POWER SYSTEM FLUIDS SUBCOMMITTEE
TRANSMISSION AND AXLE LUBRICANTS SUBCOMMITTEE
ENGINE LUBRICANTS SUBCOMMITTEE
CHASSIS LUBRICANTS SUBCOMMITTEE
MOTOR FUELS SUBCOMMITTEE
AVIATION PETROLEUM PRODUCTS SUBCOMMITTEE
DIESEL FUELS SUBCOMMITTEE
SEALS, HOSES AND ASSOCIATED PRODUCTS SUBCOMMITTEE
POWER ASSIST FLUIDS SUBCOMMITTEE
*JOINT IRON & STEEL AND NONFERROUS

SAE MEMBERS

B. W. BOGAN has been elected a vice-president of Chrysler Corp. In this position he will serve as a member of the company's Administrative Committee and Operations Committee. Bogan, who has been executive assistant to executive vice-president, will assume responsibility for purchasing and supplier relations, in addition to his present activities on organization and general operations for the executive vice-president. Bogan is chairman of SAE Detroit Section.

RICHARD A. TEAGUE has joined American Motors Corp. as assistant director of automotive styling. For the past six months, Teague was with William Schmidt Associates as executive stylist and for the two preceding years was chief stylist for DeSoto and Chrysler Divisions of Chrysler Corp. A noted collector and restorer of antique automobiles, he has won the grand prize in the National Old Car Festival three times and the Glidden Tour grand prize.

RICHARD CORY has been appointed director of marketing for Bostrom Corp. Cory has been associated with Bostrom for nine years, having served in product market research, advertising and public relations. His most recent position was sales manager. Cory taught school in Cudahy, Wis. for seven years and prior to joining Bostrom was with Young Radiator Co. for six years. He was active in the Cudahy Junior Chamber of Commerce, which awarded him its distinguished service award, and later served as vice-president of the Wisconsin Chamber of Commerce.

VAUGHAN C. REID has become executive vice-president of International Castings Corp. In this position he will manage the operations of the company's Non Ferrous Foundry. Previously Reid was president of City Pattern Foundry & Machine Co.

A. WALTER NEUMANN has been appointed general manager of Willett Truck Leasing Co. Neumann joined Willett in 1946 and worked his way up in the maintenance end of the business. He became director of purchases and maintenance in 1954 and will retain control of all new vehicle acquisitions in his new position. Neumann is an active member of SAE and is presently a member of SAE Tranportation & Maintenance Technical Committee. He is chairman of the Instruments for Preventive Maintenance Inspection Subcommittee and a member of Transportation Engineering Formulas and Cooling System Maintenance Subcommittees.

W. H. PAUL, professor of Automotive Engineering, Oregon State College, returned late in September from a summer in Europe, during which he studied developments in engineering education and trends in automotive design. He visited with manufacturers and educators in Great Britain, France, Germany and other European countries.

REAR ADMIRAL WELLINGTON T. HINES, USN, has become head of missile section of The NATO International Staff. Formerly he was deputy chief, Bureau of Aeronautics for The Navy Department.

HUGH E. KEELER, professor emeritus of mechanical engineering, University of Michigan, has been appointed director of The Hinchman Corp.

H. FOLLETT HODGKINS, chairman of the board of Lipe-Rollway Corp. and Rollway Bearing Co., has been named co-chairman of Metropolitan Development Association of Syracuse and Onondaga County, a special citizen's group formed to plan and help carry out major municipal redevelopment projects and governmetal reorganizations in the Syracuse, N. Y. area.

ROY C. INGERSOLL, chairman of the board of Borg-Warner Corp., has been re-appointed chairman of the Manufacture Committee, United States Chamber of Commerce.

COL. J. P. STAPP, national president of American Rocket Society, spoke on "Manned Versus Unmanned Space Observation" at a joint meeting of the Institute of Radio Engineers and the American Rocket Society on September 15. Stapp is chairman of the Aeronautical Laboratory with the Department of the Air Force at Wright Air Development Center, Wright-Patterson Air Force Base in Ohio.

G. L. COLEMAN has become vice-president and general manager for National Truck Rental Co., Inc. In this capacity he will be in charge of Washington, D. C. operation of Avis Rent-A-Car and National Truck Leasing Co. Previously Coleman was city manager with The Hertz Corp. in Atlanta, Ga. He was chairman of SAE Baltimore Section in 1951.

continued

Bogan

Teague

Cory

Neumann

SAE MEMBERS

— continued —

CARL O. TONGBERG has been made executive vice-president and director of ESSO Research & Engineering Co. Previously he was president of Jersey Production Research Co.

WALTER E. SCHOCK has been appointed executive engineer in Automotive Engineering section of Bendix Products Division, Bendix Aviation Corp. Schock joined Bendix in 1940 as laboratory technician specializing in vacuum power braking equipment. In 1955 he was appointed development engineer in charge of the development and test laboratories. He became executive sales engineer in 1956.

JOHN P. CASSERLY has been named general sales manager of Automotive Division of Electric Storage Battery Co. Casserly joined Electric Storage Battery Co. in 1937. He became manager of manufacturers' sales in 1949 and manager of national accounts sales, Automotive Division in 1955.

WILLIAM L. PETERSON, formerly director of sales engineering for White Motor Co., has been appointed manager of the Philadelphia branch, White Truck Division, White Motor Co. Peterson joined White in 1957 after 10 years service with Timken-Detroit Axle Co.

ARTHUR G. BAITZ has been named director of sales training for Fulton Sylphon Division of Robertshaw-Fulton Controls Co. Baitz has been Fulton Sylphon's district sales manager for the Philadelphia-Camden area since 1954. Prior to that he was sales representative in the company's Detroit office.

GILBERT C. BELLISTRI recently became sales engineer for American Oil Co. His previous position was project engineer.

CLARENCE R. MALLON has become senior engineer at Aeronca Mfg. Corp. Previously he was structures engineer with Bell Aircraft Corp.

H. E. CHESEBROUGH, SAE councilor for 1959–1960 and past SAE vice-president representing Body Activity, has been made chairman of the Industry Committee for The University of Michigan, College of Engineering. The committee has been organized to support education and research throughout the Engineering College. Chesebrough is vice-president and divisional general manager of Chrysler Corp.

Other SAE members serving on the committee are **D. F. Caris** (secretary) and **C. A. Chayne**, past SAE councilor, both of General Motors Corp.; **Ralph H. Isbrandt**, of American Motors Corp.; **Charles H. King**, of Clark Equipment Co.; **Andrew A. Kucher**, of Ford Motor Co.; **B. D. McIntyre**, of Monroe Automobile Equipment Co.; and **H. R. Steding** of Chrysler Corp.

D. F. CARIS, engineer in charge, Power Development Engineering Staff with General Motors Corp., also serves as chairman of the Subcommittee for Equipment. **Wallace S. Berry** of American Motors Corp.; **Charles C. Dybvig**, of Dana Corp.; past SAE vice-president representing passenger car activity, **W. H. Graves** of The University of Michigan; and **A. L. Haynes** of Ford Motor Co. are also members of this committee.

H. R. STEDING, executive engineer, product programming for Chrysler Corp., is chairman of the Sub-Committee for Planning.

FRED A. THAHELD has been named president of U. S. Systems, Inc. Formerly he was chairman of the board for Turbo Dynamics Corp.

R. H. JACKSON has become development manager for Cia. Hulera El Centenrio, S. A. in Mexico. Previously he was with Firestone Tire & Rubber Co., Ltd. in Bombay, India as technical service manager.

ALEX HOSSACK has become chief engineer for Product Engineering Division of Simmonds Aeroccessories, Inc. Previously he was manager of Hydro-Mechanical Engineering department with Simmonds.

LeGRAND TERRY has been appointed eastern regional sales manager, Mobile Hydraulics Division of Vickers, Inc., Division of Sperry Rand Corp. Terry joined Vickers in 1951 and most recently served them as district manager of Mobile Hydraulic Division's Detroit office.

JOHN J. HOUSE has become government representative for Detroit Diesel Engine Division of General Motors Corp. Formerly he was government sales and contract representative with R. G. LeTourneau, Inc.

H. MAYNARD SNOW, formerly production manager for Mack Trucks, Inc., is now general manager of Industrial Finishing Corp.

DAVID A. STODDART has been appointed Falcon resident engineer in Loraine, Ohio for Ford Motor Co. Previously he was Ford's Louisville Assembly Plant's quality control manager.

ROBERT H. PINNEY has become a member of the technical staff at the Vehicle Development Laboratory of Space Technology Laboratories, Inc. Previously he was head of Missile Support Branch, Engineering Division of Ordnance Tank Automotive Command in Detroit.

W. H. VAUGHN has become divisional sales manager at the Detroit office of Firestone Steel Products Co. His previous position was factory manager.

JEAN CLAUDE LANOIE has become engineering superintendent for Dumont Express, Ltd. Previously he was engineering supervisor at Provincial Transport Co.

ROY E. SUNDAY has joined Stroh Die Casting Co. as chief estimator. Previously he was with Schultz Die Casting Co. in a similar capacity.

MARTIN J. UNGER, formerly an engineer for Grumman Aircraft Engineering Corp., is now an engineer at North American Aviation, Inc. During 1956–1958 Unger was class representative to SAE at Northrop Institute of Technology.

JOHN W. WHITE (retired) holder of many hydraulic brake patents, is now using his skills to develop surgical instruments. Already marketed and in use are a wound-clip applicator for fast surgical closures; a relaxing valve for vacuum socket artificial legs; a nerve displacer for disc operations on the spine; a hip drill for use with a hip nail to hold a broken femur. . . . And right now, he's planning a six weeks' trip to Papeete. White joined SAE in 1917.

Tongberg

Schock

Casserly

Peterson

Terry

White

GILBERT WITTLIN has become design engineer for Autonetics. Previously he was tool engineer with Boeing Airplane Co.

C. E. STRYKER, president of Maysteel Products, Inc., was elected to the board of directors of the Pressed Metal Institute.

V. KUPPU RAO is a trainee in the Mechanical Engineering Department of Cornell University. He is studying under the International Cooperative Administration's Technical Teachers Training Program. Previously he was a lecturer in the I. C. E. Department at Indiana Institute of Science.

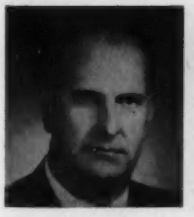
R. M. ALDWINCKLE, who is employed by the Royal Canadian Air Force, is presently taking post graduate courses in guided missile and astronautical engineering at the University of Michigan. Previously he was director of instrument and electrical engineering for the Royal Canadian Air Force.

C. M. AUBLE, formerly design engineer for Douglas Aircraft Co., is now development engineer at Aerojet General Corp.

RAYMOND J. CARTER has joined the Ottawa Steel Division of Young Spring & Wire Corp. as automotive research and development engineer. Previously he was chassis engineer in charge of advanced design for Diamond T Motor Truck Division of White Motor Co.

JACK L. ROBERTS has been appointed general sales manager of Wells Mfg. Corp. For the past three years, Roberts was associated with Airtex Products, Inc. as sales manager and prior to that he was replacement sales manager for Wausau Motor Parts Co.

E. R. GAMIEL has been appointed sales manager for Goodyear Pumps, Inc. Formerly he served New York Air Brake Co. as sales engineer, and prior to that, he was with West Coast District Sales Office of Roper Corp. Gamiel has been a representative at the current Pump Standardization Conferences for the Chemical Industry which is co-sponsored by Manufacturing Chemists Association and Hydraulic Institute.



Roberts

Gamiel

J. W. S. WHEATLEY has joined the sales department of Robby's Tire Co. Formerly he was mechanical engineer for Sinclair Refining Co. Wheatley was secretary and chairman of SAE Baltimore Section in 1944–1945.

ARMAN MOORADIAN, previously designer for Chevrolet Division of General Motors Corp., is now design engineer at American Motors Corp. Mooradian is attending the Lawrence Institute of Technology to complete his education in mechanical engineering.

EMIL ZOERLEIN has become vice-president in charge of engineering at Novi Diesel Engine, Inc. Previously he was with Ford Motor Co. as manager of Engine Experimental Fabrication Department.

CHENG SHIH has become staff engineer at Nuclear Division of The Martin Co. Previously he was with Aeronca Mfg. Corp. in a similar capacity.

JOHN R. PRIOR has become axle and brake engineer at GMC Truck & Coach Division of General Motors Corp. Previously he was staff engineer for Cadillac Motor Car Division of General Motors Corp. at their Cadillac Cleveland Ordnance Plant.

ROBERT C. BARTH, formerly assistant chief project engineer for Fairchild Engine Division of Fairchild Engine & Airplane Corp., is now staff engineer in the research department of Caterpillar Tractor Co.

LOUIS CIMBORSKY, formerly sales engineer for Linden Diesel Service & Parts, is now owner of Jersey Diesel Sales.

GEORGE A. DAUM has become western division sales manager with Cummins Engine Co. Formerly he was manager of engine sales for Wright Aeronautical Division, Curtiss-Wright Corp.

CHARLES E. COOK, formerly a student at Purdue University, has joined North American Aviation, Inc. as dynamics engineer. Cook was chairman of SAE student chapter at Northrop Aeronautical Institute in 1954.

CHARLES C. McLEAN, formerly a junior brake lining engineer for Inland Mfg. Division, General Motors Corp., is now a brake lining engineer at H. Krasne Mfg. Co.

PAUL THERON HUGHES has joined Steffke Freight Co. as director of maintenance. Previously he was superintendent of maintenance for Burlington Truck Lines.

C. C. CUPP, formerly sales manager for Firestone Steel Products Co., is now at the company's Akron plant.

DAVID A. REISMAN, previously mechanical engineer at Teleregister Corp., is now missile systems engineer with Republic Aviation Corp., Missile Systems Division.

W. BRYANT GEMMILL was elected honorary secretary-treasurer of the Pressed Metal Institute at their annual meeting Sept. 13–18. Gemmill is vice-president and treasurer for American Stamping Co.

H. JOSEPH CHASE has been made vice-president and general manager of Aviation Division of the Radio Corp. of America. Previously he was vice-president in charge of maintenance operations at Lockheed Aircraft Service, Inc.

THOMAS G. McNAMARA has become research engineer, materials for North American Aviation, Inc. Previously he was chief metallurgist at Lycoming Division of Avco Mfg. Corp.

THOMAS J. KIELY has retired as manager of the Chicago regional sales office of American Bosch Division of American Bosch Arma Corp., after serving the company for 37 years. Kiely plans to reside in Largo, Fla.

ROBERT S. PLEXICO, previously chief truck design engineer, has become assistant chief engineer on a special assignment for Chevrolet Motor Division of General Motors Corp. He has been a member of both the SAE Truck and Bus Activity and the SAE Truck and Bus Technical Committees since 1952 and is group leader on the SAE Cooperative Engineering Program Committee for 1959.

WALTER F. PRIEN, JR., formerly principal engineer at Battelle Memorial Institute, is now development engineer for Thomas Industries, Inc.

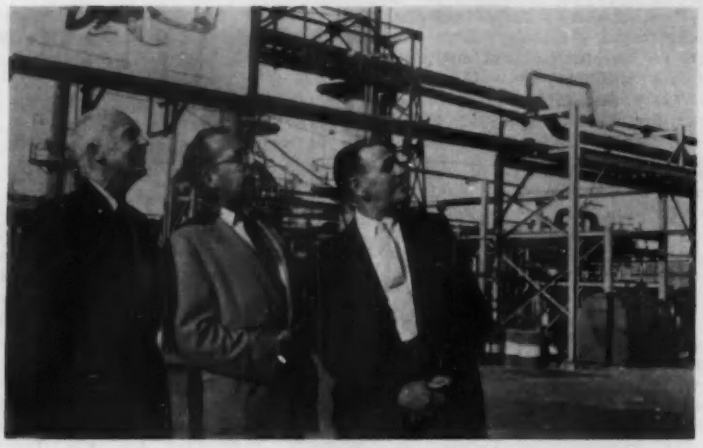
Obituaries

JOHN H. CLAREY . . . (M'46) . . . service representative with Douglas Aircraft Co., Inc. . . . died August 11 . . . born 1913.

HALSEY R. JONES . . . (M'50) . . . district manager, Timken Roller Bearing Co. . . . died August 28 . . . born 1904.

R. T. RILEY . . . (M'42) . . . president, Canadian Pratt & Whitney Aircraft Co. . . . died June 24 . . . born 1909.

H. J. SWANSON . . . (M'30) . . . partner, Swanson Marchy Co. . . . died August 30 . . . born 1893.



THE 4TH OF GM RESEARCH'S LINE OF AUTOMOTIVE GAS TURBINES (GT-305) weighs only 650 lb and delivers 225 hp at a specific fuel consumption of 0.55 lb/hp hr. This latest engine is used to power the Firebird III and has been installed in a tracked military vehicle and a heavy duty truck. Prototype engines designated the GMT-305 are being built by GM Allison Division to obtain user evaluation of the regenerative gas turbine in many fields of application. John S.Collman of General Motors Corp. spoke on the GT-305 at Cleveland Section September 14.

Members from Cleveland Section toured Sohio #1 Refinery during their September meeting. Present at the tour were (left to right) John S. Collman, speaker of the meeting; Robert Pejeau, diesel activity chairman; and Leo L. Young, section vice-chairman.

SAE SECTIONS

GROUND EFFECT VEHICLES were revealed in practical model form at Detroit Section's White Sulphur Springs meeting September 25-27.

THE LEVA CAR, developed by Ford's A. A. Kucher, was described as a vehicle which does not ride on wheels but on a thin film of air allowing it to slide rather than roll.

The wheels are replaced by Levapads, flat smooth discs with holes in them. Air is forced through the holes creating a frictionless film of compressed air 0.010 of an in. thick.

The plastic model, which is supplied with a rubber tube through which air may be blown to activate it, is being inspected by A. L. Haynes (left) and Dr. A. A. Kucher.

A film narrated by Kucher showed the development of the Leva Car from his conception of the principle to an actual man-carrying vehicle. He proposed that in the future the car may be run on rails.

A CHRYSLER "GROUND EFFECT" VEHICLE, currently being developed for military use, was discussed by Chrysler's C. C. Utz (left). This vehicle which uses ducted fans for an air supply rides 10 to 12 ft. from the ground. Talking with Utz is Glen Fitzgerald, chairman of the session.

Students present at Chicago Section's meeting held September 21 were from Riley, St. Joseph, and Washington High Schools. They are (clockwise starting at nearest table corner) J. Opaczewski, K. Barna, R. Remenih, L. Copeland, J. Weis, J. C. Straub of Wheelabrator Corp., acting host, L. Nowacki, L. Culp, M. Pietraszewski, and J. Wierschem.

MULTIPLE SHOE BRAKES are capable of absorbing 64% more energy than conventional shoe brakes and enable a vehicle to stop in 58% of the distance required by standard shoe type brakes under identical conditions, Paul F. Black of B. F. Goodrich Co. told SAE's Chicago Section on September 21.

SPECIAL DRAINS have to be used in main highways across Salt Lake City to prevent flood water from undermining the surface. The city is faced with the problem of retaining the salt and preventing water from dissolving it, Col. Rulon J. Ballard of the Utah State Road Commission told the Salt Lake City Group on September 23.

CORNELL UNIVERSITY is conducting a series of tests on automobile tires to produce data on the relationship between slip angle, side force, load, braking or driving torque, aligning torque, drag and camber torque, the aim being: to develop sufficient theory to accurately predict the behavior of a new tire before it is built and tested, William F. Millikan told Buffalo Section September 23.

William E. White (left), regional vice-chairman, discusses aspects of the technical presentation with Paul F. Black, speaker at Chicago Section's September meeting.

Hawaii Section heard Lloyd G. Thomas speak on "Forged Pistons, Design and Characteristics" and Dick Sparrow speak on "Piston Ring Design and Testing" at its September 22 meeting. Present at the meeting were (left to right) Harry K. Sproull, section chairman; Dick Sparrow, representative, Ramsey Corp.; Lloyd G. Thomas, district manager, Toledo Products Co.; and George K. Sereno, section secretary.

SAE SECTIONS

Dr. John M. Dempsey illustrates his talk.

R. R. Gutteridge

A MAJOR TECHNOLOGICAL BREAKTHROUGH will be required for long range answers to Space Age materials problems. Metals exhibit 1/10 to 1/100 of their true theoretical strength due to impurities and imperfections. However, certain advances have been made in solving these problems. The flexural strength of a single germanium crystal has been increased thirty-fold by testing under an etching solution.

Dr. John M. Dempsey (above) of Honeywell Regulator Co., who spoke at Twin City Section September 9 on "Space Age Impact on Materials Technology," explains progress in high temperature materials.

R. R. Gutteridge (above left) was technical chairman for the evening.

Northern California Section held its September meeting at the Engineers Club in San Francisco. Harrison Sigworth (left) technical chairman of the meeting greets (left to right) Prof. A. L. London, discusser; Prof. E. S. Starkman, co-author; Prof. L. S. Jacobsen, discusser; and W. E. Sytz who was the main speaker.

SAE Section Meetings

DETROIT

December 7 . . . 3 Simultaneous Technical Sessions. Passenger Car Meeting. Speakers: Robert Schilling, Chevrolet, GMC, O. J. Winkleman, Engineering Division, Chrysler Corp., F. J. Hooven, Advanced Ford Car Engineering, Ford Motor Co. "New Dimensions to Future Suspensions." W. A. McConnell, Engineering Staff, Ford Motor Co. "How Good is Testing?" Body Activity Meeting. Speaker: O. H. Biggs, vice president, research and engineering, Sylvania Lighting Products. "Electroluminescent Lighting." Coffee Speaker: Rev. Henry F. Birkenhauer, S. J., John Carroll University, Cleveland. Rackham Educational Memorial, 100 Farnsworth. Dinner 6:30 p.m. Meeting 8:00 p.m.

FORT WAYNE

December 16 . . . Plant Tour. Joslyn Steel Mill, Ft. Wayne, Indiana

METROPOLITAN

December 3 . . . Paul Ackerman, vice president — engineering, Chrysler Corp. will present a paper on the progress and forecast of the design for economy of standard sized automobiles. Brass Rail Restaurant, Fifth Ave. and 43rd St., New York. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

December 17 . . . Dallas Sherman, assistant to administrative vice president, Pan American World Airways, Inc. "The Bishop's Boys — Human Engineering for the First Flight." Henry Hudson Hotel, 57th St. and 9th Avenue, New York. Meeting 7:45 p.m.

PHILADELPHIA

December 2 . . . Plant Tour, Ford Motor Company, Chester, Pa. "The New Ford Falcon — An Engineering Survey." Plant Tour 2–4:30 p.m. Dinner Meeting, Springhaven Country Club.

SAN DIEGO

December 12 . . . Ladies Day. Tea Dance and Fashion Show. Display of "Compact" cars. Kona Kai Club, San Diego. 12:00 Noon to 4:00 p.m.

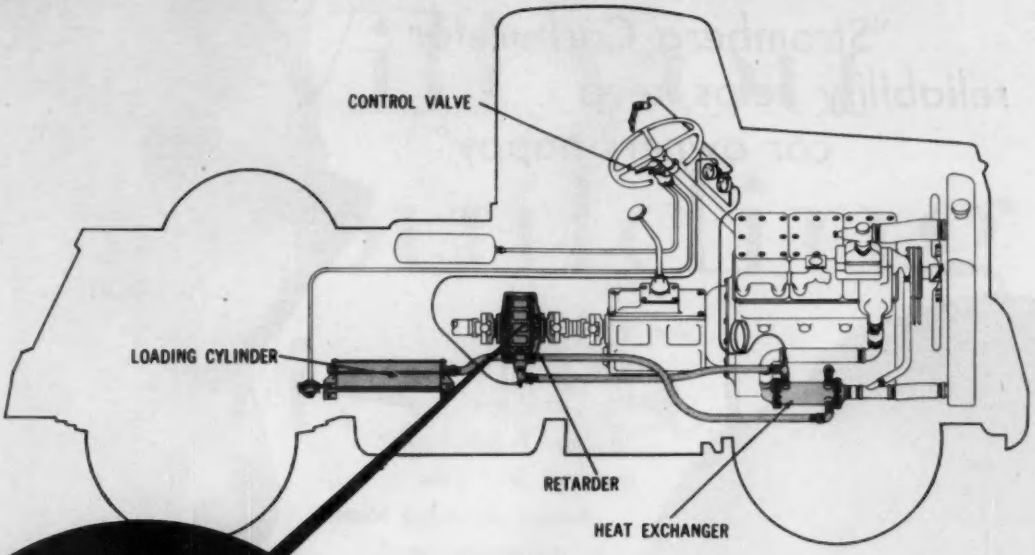
It's Dynamic...

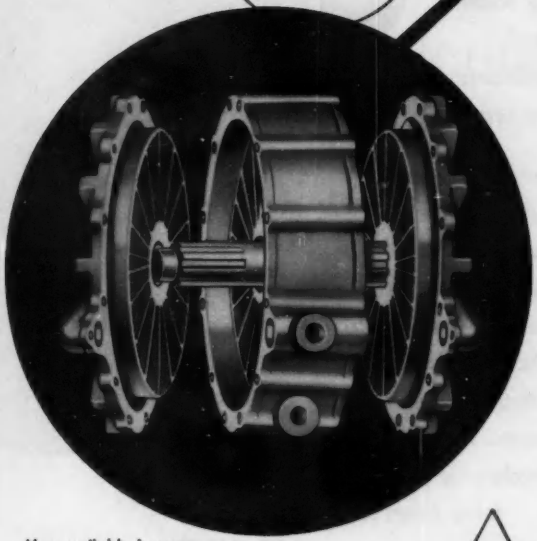
LEADING TRUCK MAKERS ADOPT THOMPSON RETARDER

New dynamic system cuts speed without use of brakes, means new safety and economy for users

Several leading truck manufacturers are offering the new lightweight, low cost Truck Retarder, developed and manufactured by Thompson's Michigan Division. This new, auxiliary system gives drivers better control of their vehicles, helps prevent "runaways". Service brakes remain cool and ready for emergency stops.

Users report major savings through substantially reduced brake maintenance costs, increased tire life, faster trips and less engine maintenance. Safety is increased, costs are reduced.





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To slow truck, driver moves air control valve. This connects normal air supply with loading cylinder in which fluid is stored. Air causes piston in loading cylinder to force fluid into the retarder unit. Unit is comprised basically of a rotor and stator with radial fins. Rotor is attached to the drive line. Stators which comprise the outer housings are mounted between the frame rails on a cross member. Fluid injected from loading cylinder absorbs energy through fluid friction due to the action of fluid reacting between stator and rotor. Heat is dissipated by fluid circulating through heat exchanger. *Retardation is immediate and positive.*

For complete information concerning the Thompson Retarder, write or call for illustrated brochure.

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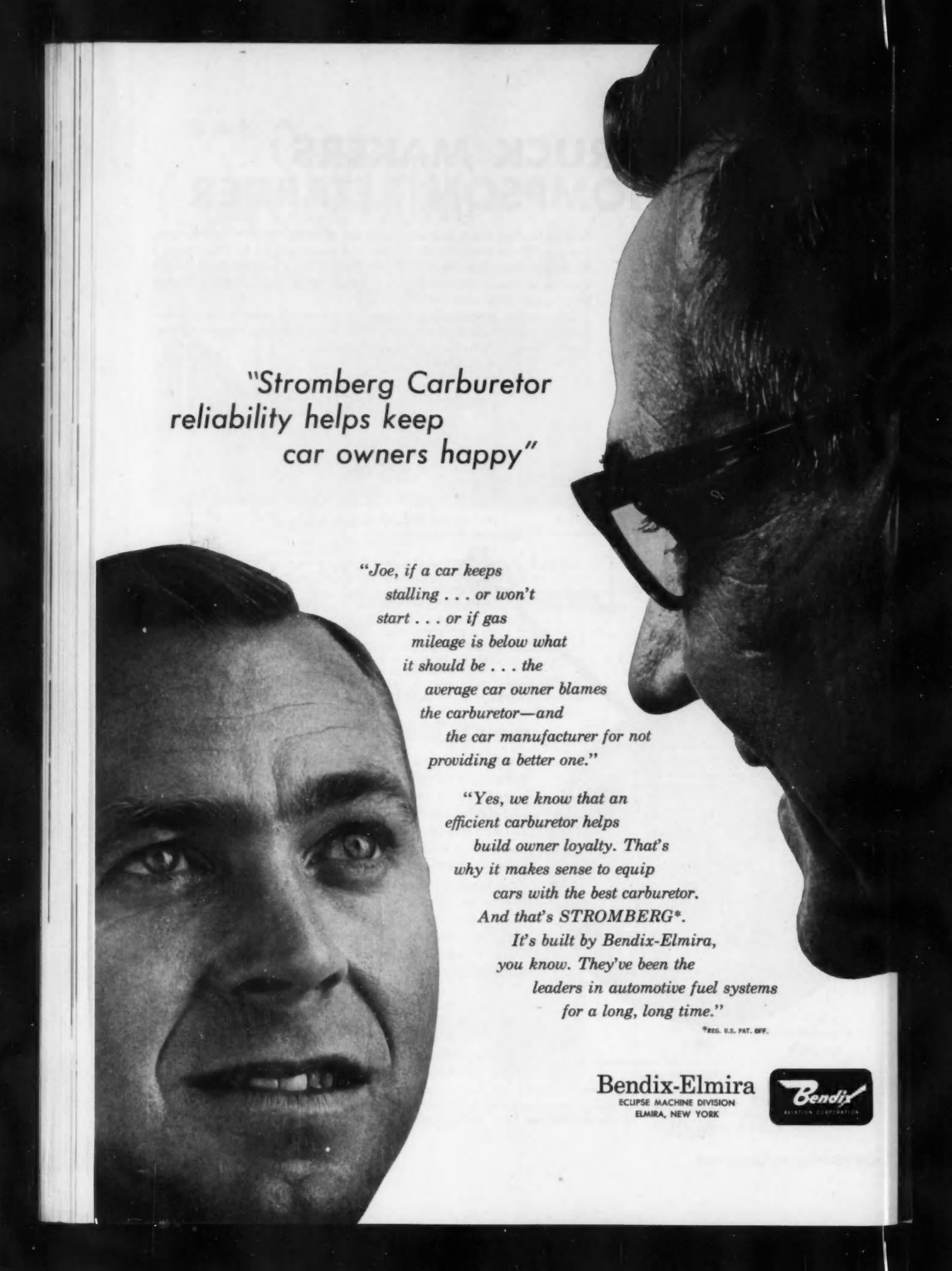
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"Yes, we know that an efficient carburetor helps build owner loyalty. That's why it makes sense to equip cars with the best carburetor. And that's STROMBERG*. It's built by Bendix-Elmira, you know. They've been the leaders in automotive fuel systems for a long, long time."
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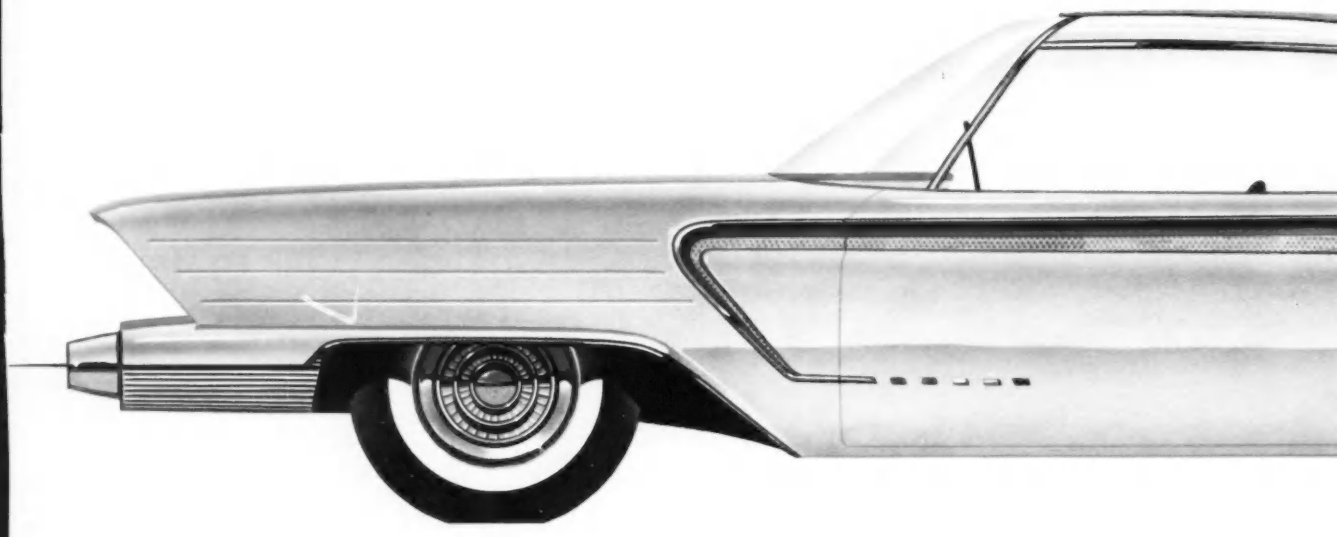
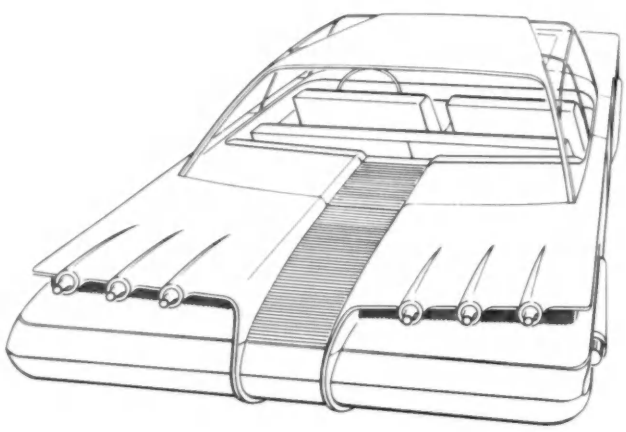


The Pele *(Pay-lay)*



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Briefs of SAE PAPERS

continued from p. 6

Recent Developments in Tires, C. R. McMILLEN. Paper No. 84U. Developments in tires designed to meet requirements of vehicle and aircraft designers, and improvements made in materials and methods applying to all types of tires; rubber and rubber compounds, use of carbon black for rubber reinforcing, and rubber chemicals; manufacturing methods and equipment; test equipment; Goodyear's proving ground in Texas; requirements of passenger car tires and future objectives such as elimination of spare tire and nylon flat spotting.

Spark Arresters — Their Design and Value, M. HIBBARD. Paper No. 85U. Fundamental principle, construction and various flow arrangements; experience made by logging firms in fir and pine regions concerning exhaust spark caused fires shows that area of greatest need for arrester is that of gas engines, and power saws; Interim Standard proposed by U. S. Dept. Agriculture establishing minimum performance requirements of arresters to be used in proximity to grass, brush, timber and similar cellulose materials, and methods for rating performance and selection of size.

Turbo-Charged Diesel Engines for Highway Use, E. B. OGDEN. Paper No. 87T. Comparison of cost figures between turbocharged and naturally aspirated engines in highway use, taking into account turbocharger maintenance and other factors to evaluate increase in horsepower; necessity for higher horsepowered engines, to traverse toll roads and interstate highway system, with considerably heavier loads is pointed out.

Diesel Truck Transport in Yukon, N. GRITZUK. Paper No. 87W. Description of small, highly integrated highway haulage operation serving two mining companies; United Keno Hill Mines, Ltd. and Cassiar Asbestos Corporation Ltd.; for UKHM annual concentrate out-haul is 35,000 tons and for CAC annual fiber outhaul is 31,000 tons; characteristics of operations; operating costs for each of two fleets; summary of products hauled; cost of operating maintenance shop, major vehicle component specifications tabulated.

Design and Performance Features of Thompson Hydraulic Retarder, E. J. HERBENAR. Paper No. 88V. Basic principles of Thompson retarder developed to provide means of decelerating commercial vehicles and for controlling forward speed while descending long grades; system transforms rolling energy into heat, most of which is dissipated through vehicle's cooling system; retarding action is applied through petroleum base hydraulic fluid system; mid mount and axle mount installation; components; performance data.

Liquid-Cooled Brakes for Commercial and Off-the-Road Vehicles, J. D. DUDLEY. Paper No. 88U. Approach employed by Wagner Electric Corp. to dissipate energy that must be absorbed by braking system while retarding vehicle on long grades incorporates use of liquid cooling; disk brake system is designed for air-over-hydraulic actuation using power cluster; coolant used is same as that in engine cooling system, circulated through brake and back to radiator by positive displacement pump; results of tests.

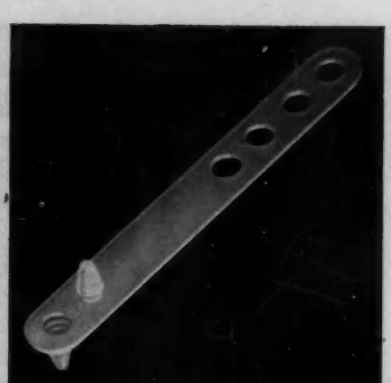
Exhaust Brake Effectiveness, B. JOHNSON. Paper No. 88W. Compression brake, developed by Power Brake Equipment Co. consists of gate, poppet or butterfly valve bolted directly to exhaust system; valve is air, hydraulic, vacuum or electrically actuated and in some instances mechanically; efficiency is governed by engine displacement, design and condition; effectiveness of brake as retarder in controlling vehicle on down grades; other advantages are increased life of lining, lower maintenance costs and control of engine temperature.

In Rock — Break for Contractor, K. F. PARK. Paper No. 90U. Factors to consider in choosing between methods of rock removal — ripping or drilling and shooting; ripping in terms of its acceptance to contractor; general principles and conditions of rock ripping; procedures which add to efficiency of ripping; use of tools; tandem ripping; use of portable refraction seismograph and its advantages in judging possibilities of ripping.

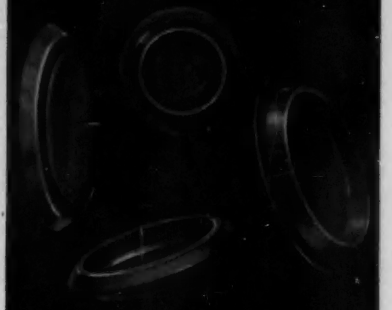
Blasting in Marginal Areas, D. BODDORFF. Paper No. 90V. Factors to consider in choice of rock removal methods; mechanism of blast, drilling of blast holes and factors affecting amount of explosive charge per hole; one of most important advantages of blasting material over other forms of rock removal such as straight digging or ripping, is factor of increased production; tabulation of costs taken from actual blasting job in New Jersey serves as example of total cost analysis of material that could possibly be ripped.

continued on p. 130

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Readers Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.



FLEXIBLE, STRONG cable clamps of ALATHON save installation time, resist vibration, chemicals, grease and water. (Molded by Fastex Division of Illinois Tool Works, Des Plaines, Illinois.)



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Briefs of SAE PAPERS

continued from p. 129

General Economics of Farming for Future, M. S. PARSONS. Paper No. 91T. Trends and changes which have been taking place during last 20 yr in United States farming; technological changes and farm mechanization; use of tractors, motor trucks, automobiles, and horses and mules on United States farms; future trends toward commercial farm.

Farming for Future, W. M. CARLETON. Paper No. 91U. Review of U. S. Dept. of Agriculture research on machines and techniques with reference to areas of mechanization of importance: major field crops, special crops, and farmstead mechanization; progress in some areas of farm operations; agricultural materials handling; farmstead engineering; machines and techniques for selected major field crops, analysis shows that largest changes for major field crops will be in techniques rather than in completely new machines.

Hydrostatic Transmissions for Vehicles, E. H. BOWERS. Paper No. 92V. Types of hydrostatic transmission and requirements of hydrostatic units; advantages and comparative performance; performance in vehicles, such as material handling truck and dumper; hydrostatic drives for tractors and shovels; effect of hydrostatic transmission on performance of vehicle, and aspects of integration of drive into machine design; application considerations.

Hydrodynamic Split Torque Transmissions, P. BLOCH, R. C. SCHNEIDER. Paper No. 92W. Mathematical investigation of systems with two parallel power paths of power dividing and power uniting type; basic equations for split torque transmissions and engine transmission packages; performance characteristics of various transmissions; overall effect of engine transmission package on engine speed, output horsepower and torque and overall efficiency; summary of results.

Historical Review of Rough Terrain Fork Truck Development Program, D. W. McKEE, C. B. ROGERS, J. R. SUSAG. Paper No. S172. Features of three types of military lift trucks, developed by Clark Equipment Co. for U. S. Army; trucks are designed to lift and carry 6000, 10,000 and 15,000 lb loads through salt water up to five ft

continued on p. 133

Where the Shift-Ratio Per Mile Is High, the shift is to LIPE CLUTCHES

Stop-and-go . . . creep-and-crawl . . . uphill-downhill . . . wherever the overall frequency of shifting is high, it's hard to keep clutch maintenance costs low.

Fleet operators know it's not the number of miles per year that put a clutch to the cost test. It's the *number of engagements per mile.*

That's why so many operators are converting entire fleets to Lipe Heavy-Duty DPB Clutches . . . both on new trucks and as replacements of original equipment.

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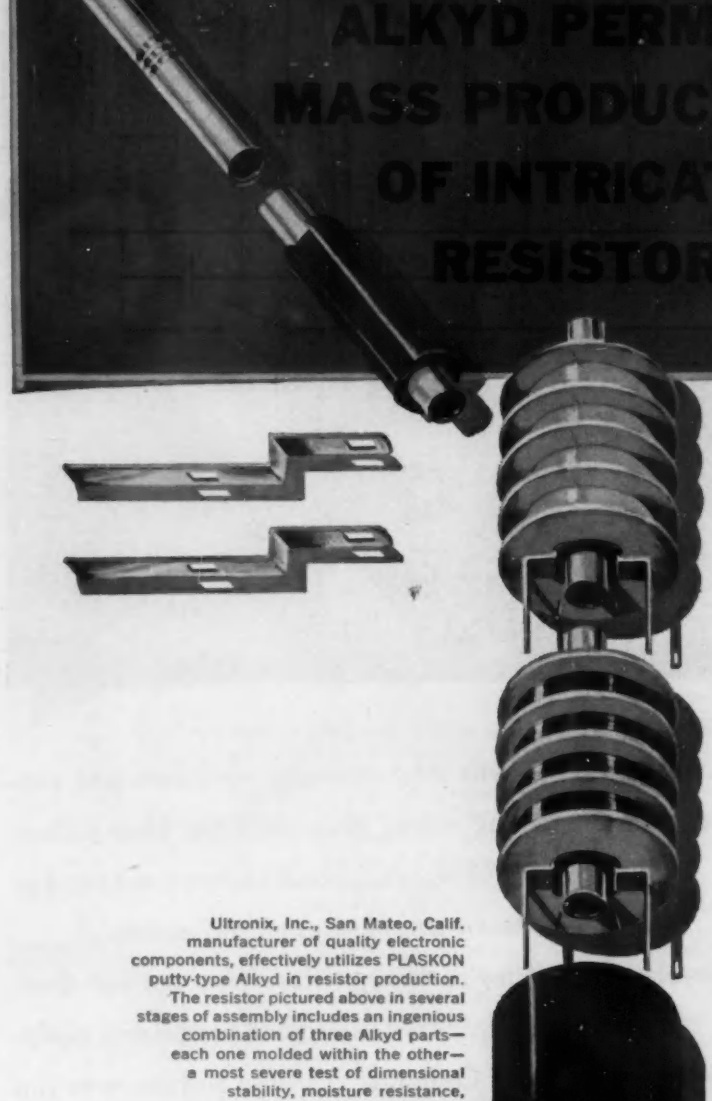

Encapsulation with putty-type Alkyd satisfies need for reliability by resistor maker and customers.

Today's creative engineers design with PLASKON Alkyd in mind for the manufacture of delicate electronic components. Here are reasons why electronic engineers prefer PLASKON putty-type Alkyds as *the* encapsulation medium:

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- Thermal conductivity helps to dissipate heat faster, resulting in less change in resistance value before and after encapsulation.
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Ultronix, Inc., San Mateo, Calif. manufacturer of quality electronic components, effectively utilizes PLASKON putty-type Alkyd in resistor production. The resistor pictured above in several stages of assembly includes an ingenious combination of three Alkyd parts—each one molded within the other—a most severe test of dimensional stability, moisture resistance, and consistency in performance. This resistor is built to meet or exceed all requirements of MIL-R-93B and MIL-R-9444.

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Briefs of SAE PAPERS

continued from p. 130

in depth, over sand beaches, rough terrain, up grades of 45% at minimum speeds of 2.0 mph, and over-the-highway at minimum speeds of 15 mph loaded; loader mechanism and other special features.

Use of Diesels in Light Load, Short Haul Truck Service, J. G. HULL. Paper No. S174. Two basic reasons which justify purchase of diesel power for this service are lower overall cost per mile for diesel as compared to gasoline and greater vehicle availability; to obtain complete picture of operating, fuel, and lubricating oil cost, depreciation and maintenance factors must be considered; diesel vs. gasoline operating and ownership costs of local pick-up and delivery service calculated; examples of installations.

Engineering Know-How in Engine Design — 7. Paper No. SP163. (Milwaukee Sec) 1959. Seventh of series of annual lectures planned by Milwaukee Section, consists of following papers: Solving Automotive Engine Roughness Problems, J. O. ANDERSON, 17 p; Viscous Torsional Vibration Dampers, R. D. RUMSEY, 10 p; Engine Mountings for Vibration Control, J. W. SHERRICK, 19 p; Design and Development of Air Intake Silencers and Air Cleaners, J. J. DREZENES, 12 p; Exhaust and Intake Silencers, R. L. HOYLE, 15 p.

MATERIALS

Expanding Polymer Horizon, J. H. DuBOIS. Paper No. 82T. Methods and materials employed in manufacture and use of polymers; needs of automotive industry and examples of applications; tabulation of contemporary thermoplastic materials chart.

Application of Cumulative Fatigue Damage Theory to Practical Problems, W. F. HOFMEISTER. Paper No. S163. Application of H. T. CORTEN — T. J. DOLAN relationship to prediction of total cycles to failure for heterogeneous load spectrum, made on lift truck steel chains operating over sprockets on testing machines in Chain Belt Co. Laboratory; in all cases tested, methods for predicting cycles to failure for steels subjected to varying load ranges give good correlation with experimental evidence.

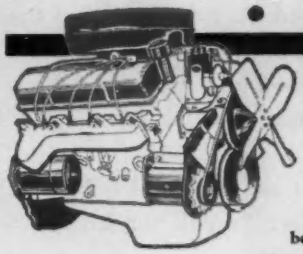
PRODUCTION

Quality Assurance for Missile Reliability, C. W. HARRIS. Paper No. S160. Program at Lockheed Missiles and Space Div; example of differences in reliability requirements associated with two programs; Lockheed Polaris, and typical satellite; position of Quality Assurance and Test Services in organization; operational concept and main steps of program.

Missile Reliability from Production and Logistics Viewpoint, E. J. LANCASTER. Paper No. S171. Relationship between design and quality control functions in support of reliability program; reliability problems and their implication to design and quality control; some quality control principles and methodology which can be applied to design reliability effort are suggested.

Reliability Aspects Associated With Low Production Rates, H. G. SPILLINGER. Paper No. S173. Approach used by Reliability & Safety Control of Boeing Airplane Co., in production of devices employed in weapon systems and subsystems and components which comprise such systems; definition of reliability; concept and approach to reliability program, organization, programming, and quality control; acceptance criteria; failure and deficiency reporting, analysis, and correction; relationship with vendors and sub-contractors; training.

JOHNSON *tappets*



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Here is a new reverse-current cleaner that performs two operations at once. (1) It removes the oily soils normally requiring an alkaline cleaner . . . and (2) it removes smut and rust bloom normally requiring additional treatment.

New Oakite 190 performs this double duty because it's a *chelated* detergent. Chelation—which makes metallic salts and oxides soluble in water—handles the removal of smut, heat scale and rust. Powerful alkaline detergency handles the removal of oil films and shop soil. As a bonus, Oakite 190 has high conductivity, rinses well in hot or cold water.

Result: new Oakite 190 insures fewer plating rejects due to inadequate pre-cleaning, *eliminates an entire operating step* in many instances.

For more details about Oakite 190, ask your local Oakite man or write to Oakite Products, Inc., 25A Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE

50 1909-1959 SCIENCE

years' leadership in industrial cleaning

Letters from Readers

. . . continued from p. 108

per, when used as a separator medium, is not satisfactory because water that collects in the pleats is absorbed or readily forced through the paper during the operation of a water separator unit. The generality is drawn that all treated paper elements can become water saturated and rendered inoperative.

A well designed and properly installed separator cartridge made of treated paper, whether pleated or of some other configuration, will not fail (by the passage of entrained water) because of water saturation, provided it is operated within the designated flow rates. The following statements are made to illustrate this:

1. Tests conducted on media show that pleated sections of water separator paper, when first immersed in JP-5 fuel, will retain water in the valleys of the pleats indefinitely and will not absorb the water or allow it to pass through under gravity.

2. This property of the separator paper media was also studied under dynamic flow conditions. The separator cartridge was first immersed in JP-5 fuel to prewet the element. Immediately following this, the cartridge was fully immersed in water for over 72 hr. The cartridge was then tested for its ability to separate water from fuel in accordance with the procedure outlined in specification MIL-F-15618E. The cartridge met the specification requirements after the residual water droplets clinging to the inner structure of the cartridge had been swept into the fuel stream. The separation of water was complete and the fuel was rendered completely free of entrained water.

3. When a correctly treated separator element, that has first been immersed in fuel, passes water, this water has to be *forced* through by a differential pressure existing across the media. The exact pressure at which this water comes through the media is directly dependent on the pore size of the media and the interfacial tension of the water versus fuel. It can be termed the water rupture pressure. This relationship is expressed:

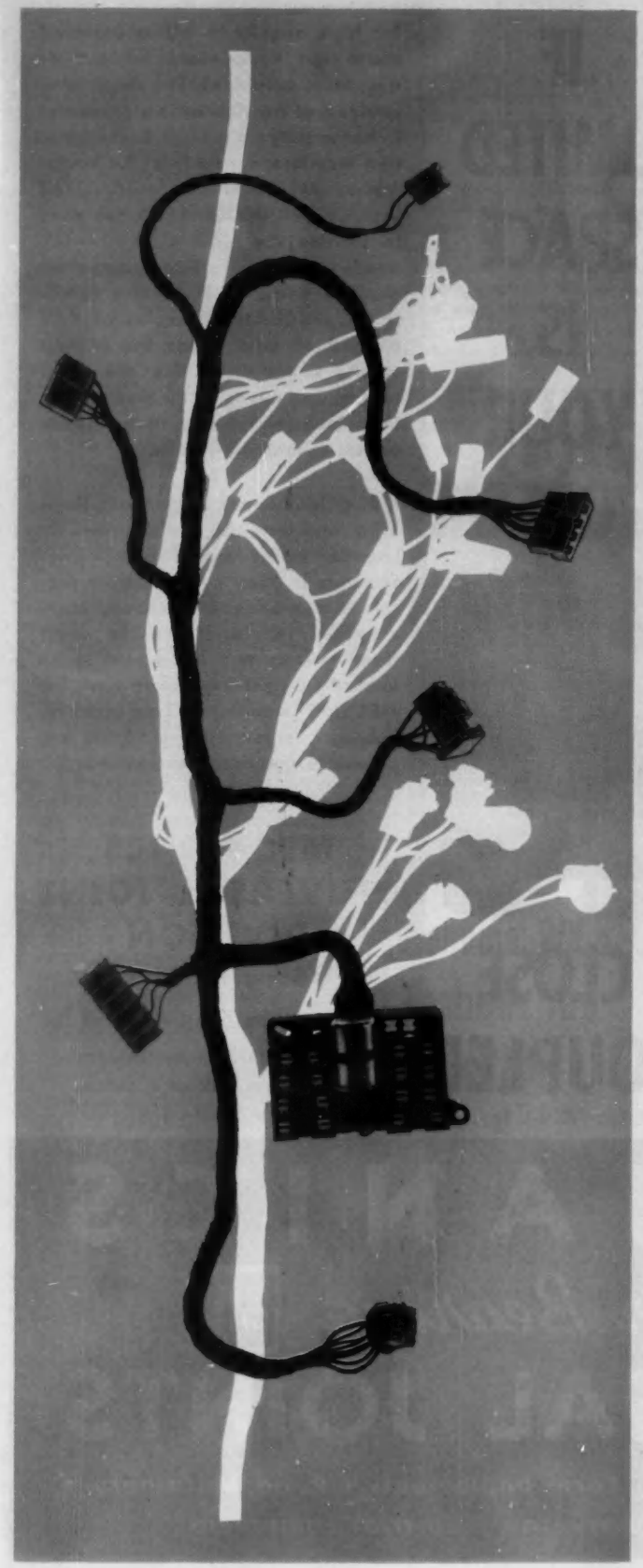
$$\Delta P = \frac{4r}{D}$$

where:

ΔP = Rupture pressure, dynes/cm^2
r = Interfacial tension, dynes/cm
D = Pore diameter, cm

Entrained water will not pass through a correctly treated paper cartridge having a sufficiently small pore size, as indicated by the pore pressure, when operating within a flow range

continued on p. 137



Packard Wiring Systems

SAVE ASSEMBLY OPERATIONS!

Packard Electric engineers strive continually to make their products less expensive and faster to install. Now they have made it possible for the already efficient automotive wiring harness to become an even more complete sub-assembly. • For example, the dome light of the Corvair is attached to the wiring harness at Packard and shipped ready to snap into the roof of the car along with the wiring. Single terminals are replaced by "Snap Fast" multiple connectors, fuse blocks and other cost-saving components. • If your present wiring harnesses do not include these advantages ask Packard Electric engineers to help work out modern wiring systems for you. Packard Electric, the world's largest producer of automotive wiring systems, has sales and engineering offices in Detroit and Chicago.

Packard Electric

Warren, Ohio

GM GENERAL MOTORS

"Live Wire" division of General Motors

If you are faced with the problem of locating a universal joint in a space where limited clearance does not permit the use of a flanged joint, MECHANICS close-coupled Roller Bearing UNIVERSAL JOINT is your solution. This joint is specially designed for operation within cramped quarters that engineers formerly considered too short to accommodate a universal joint.

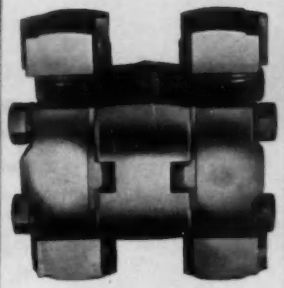
Where starts, stops and reverses are frequent—loads heavy and torque requirements severe—amid dust and moisture—MECHANICS Close-Coupled, Roller Bearing UNIVERSAL JOINTS serve dependably, safely and economically. They transmit more power—in less space—at greater angles than any other joints.

Unique features of MECHANICS Roller Bearing UNIVERSAL JOINTS make them unusually easy to install and service. The complete cross and bearing assembly can be removed simply by taking out the cap screws and separating the end yokes slightly. No flange is required for drive shaft connections. Accurately and durably built for long, heavy service, MECHANICS Roller Bearing UNIVERSAL JOINTS are inherently balanced for smooth operation.

Modern Crawler tractor design requires a F-L-E-X-I-B-L-E connection between the engine and transmission. MECHANICS Close-Coupled Type UNIVERSAL JOINTS not only provide for high angularity within cramped space but compensate for out-of-alignment conditions. The shocks and strains that crawler tractors encounter in heavy duty work often are so great that they temporarily twist the tractor frame. MECHANICS Close-Coupled Type UNIVERSAL JOINTS are designed to provide the F-L-E-X-I-B-I-L-I-T-Y needed to make efficient operation possible under such adverse conditions. MECHANICS exclusive KEY method of driving has the highest safety factor, transmits the most torque, and averts costly breakdowns that result from driving through bolts or screws that work loose.

MECHANICS key-drive strength, flexibility and balance are unanimously specified by the largest tractor manufacturers to keep huge capacity machines operating long hours, day-after-day. They can't afford to permit large tractors and equipment to be kept idle by needless down-time. Let MECHANICS engineers help build reliability into your (200 to 50,000 foot pounds torque capacity) machines.

IF LIMITED SPACE IS YOUR PROBLEM *Specify*



CLOSE COUPLED

MECHANICS UNIVERSAL JOINT DIVISION
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MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Letters from Readers

. . . continued from p. 134

that yields a differential pressure lower than the rupture pressure.

4. Assume that the specified flow rate is exceeded to the point where the pressure drop across the media is greater than the rupture pressure and water is forced through the media. If the flow is then reduced to the specified rate, the cartridge will recover its full separating ability.

Failure of a separator element to separate water efficiently from fuel then can be traced to one or more of the following reasons:

(1) The presence of a defective separator element that, through a structural defect, as indicated by low pore pressure, allows water to pass through the media.

(2) An additive in the fuel that alters the interfacial tension and possible other properties of the fuel to the point that complete separation will not occur at rated flow.

(3) The presence of a defective coalescer that will permit the passage of water-fuel emulsion to the separator element. In addiiton, a defective coalescer in a two-stage unit will permit the passage of solids to the separator cartridge and will cause the separator media to plug. The resulting increased differential pressure across the element will force the water through the media.

(4) Excessively high fluid flows through the element, causing the differential pressure across the element to increase, thereby forcing the water through the media.

(5) The prewetting of the media with water prior to fuel immersion. Although the element will resist water indefinitely, provided it is fuel-wet first, the effectiveness of its repellency is limited if it is water-wet first.

The last paragraphs of the article, under the subhead, "Quality Control," contain two proposed items that are not questioned but merit comment.

It is suggested that, "From each batch of elements, a number should be tested to failure on both solids and water. . . . Since the finished units perform only as well as the poorest element, some means should be provided for testing the performance of each and every element before delivery. Perhaps the air bubble test could be modified for production use."

Currently, samples of production elements are submitted at intervals to complete testing in accordance with applicable military specifications, such as MIL-F-8508A and in the recently issued MIL-F-15618E.

Testing of every separator cartridge on the production line is an established procedure. The test applied is the air bubble or pore pressure test suggested above. This test is not only applied to the cartridge prior to shipment but also is applied to the paper as a quality control check on the media.

• *Mr. Coker, one of the authors of the article, replies as follows: "In talking to Messrs. Brownell and Fredrickson I found that their principal objection to the paper was the statement that pleated cartridges in a horizontal position fail to remove water completely after extended periods. We postulated that these failures resulted from water wetting of the cartridge. It is this last statement with which they take issue. While they disagree with our explanation as to the mechanism of failure they state that such failures do occur; however, they suggest other mechanisms of failures. In fact, they have sufficiently recognized this problem to go to the use of nonpleated cartridges in certain horizontal units.*

After reviewing their comments I am inclined to agree with their explanations as to the mechanism of such failures. However, this is really not the issue. The point is that the unit fails, and when such failures occur the results can be disastrous. This is the point we were trying to make in the paper."

— **Editor**

ROCKFORD

Genuine ROCKFORD Features Are Patented

Features of the ROCKFORD RT CLUTCH Driven Members are covered by patents and patents pending. To give your product the full advantages of these ROCKFORD developments, it is necessary to specify ROCKFORD CLUTCHES. Let our engineers help you determine the type and size clutch best suited to help improve the power transmission control in your next model.

Small Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Automotive Spring Loaded

BW SEND FOR THIS HANDY BULLETIN Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

ROCKFORD Clutch Division BORG-WARNER

316 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

Long-life brushes for IMMERSED FUEL PUMP operation

It's one thing for a brush to combine excellent commutation with long life under normal atmospheric conditions . . . and something quite different to do this when immersed in gasoline or in gas-fume atmospheres. These little Stackpole brushes for 12-volt automotive fuel pumps do the job nicely—and were the first brushes to meet the exacting requirements involved.

Quick-filming brushes for IMMEDIATE HIGH ALTITUDE performance

No earth-surface break-in run is needed to assure satisfactory operation for Stackpole Quick-Filming high-altitude aviation brushes. They provide excellent and immediate commutation from no load to full load; from minimum speed to overspeed; and through zooming transitions from sea level to high altitudes. Life is eminently satisfactory, stability excellent. Low friction coefficient reduces brush operating temperatures and improves overall efficiency.

...better brushes for difficult applications

These milestones in better brushes for unusual conditions are typical of Stackpole brush progress along many lines. Equally important in their respective fields, are Stackpole brush developments for diesel-electric equipment, fractional horsepower motors, silicone-insulated motors, electro-plating generators, heavy-duty motors and others. For prompt brush recommendations, send details of your application to: STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE BRUSHES

for all rotating electrical equipment

Contacts • Bearings • Graphite Chemical Anodes • Grounding Anodes • Power Tube Anodes • Seal & Clutch Rings • Voltage Regulator Discs • Heating Elements • Friction Segments • Ceramic Magnets • Ferromagnetic Cores • Fixed & Variable Resistors . . . and many other carbon, graphite and metal powder products.

continued from p. 85

ness, or material of the shaft to get a satisfactory seal.

This unitized seal, so-called, has a wear sleeve as an integral part of the assembly. The wear sleeve is provided with a rubber lining which is a press fit over the shaft, sealing the space between the sleeve and the shaft and serving as a driver of the sleeve. This rubber lining is carried around the edges of the sleeve and small projections serve to locate the sleeve within the outer case. These projections wear off in service and the initial torque drag they cause soon disappears. In other respects the seal is conventional. Some of the advantages of the unitized construction are:

1. Neither wear sleeve nor sealing lip can be damaged during shipment or installation.
2. Replacement of seal automatically replaces the wear sleeve.
3. The seal is self-lubricating.
4. Installation requires no special tools or mechanical skill.

To Order Paper No. 119Y . . . on which this article is based, see p. 6.

Design of CLR Oil Test Engine Released by CRC

THE development of a common oil test engine for evaluating lubricating oils is outlined in CRC Report 301, "Development of CLR Oil Test Engine."

Results of a survey made among 40 laboratories to determine the engine's design requirements are given in addition to the technique used to arrive at these requirements.

The construction of the CLR engine is illustrated with schematic drawings and photographs of the prototype model.

To Order CRC Report 301 . . . on which this article is based, see p. 6.

Standard PTO Drives for Tractors Is Aim of 3 Groups

Based on paper by

Merlin E. Hansen

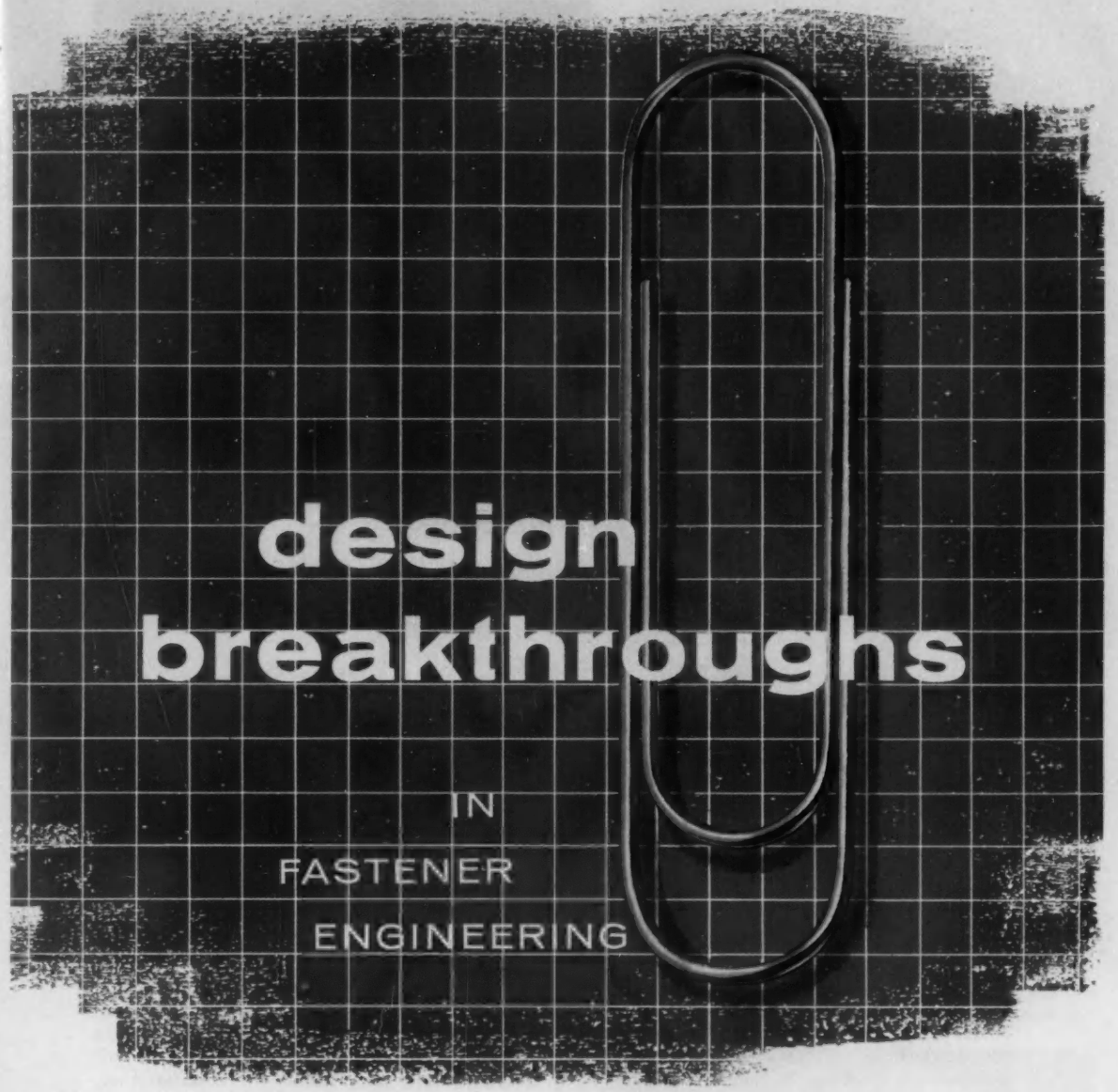
John Deere Tractor Research and Engineering Center

TODAY three industry-supported groups are developing recommendations and standards that will enable power take-off drives for agricultural tractors and implements to be interchangeable, safe, and efficient.

The groups supporting this work are the Farm Equipment Institute Advisory Engineering Committee, American Society of Agricultural Engineers Power and Machinery Technical Committee, and SAE Tractor Technical Committee.

The chief function of the FEI group

continued on p. 146



An important breakthrough in fastener design a good many years ago was the common paper clip. And, although DOT is not a manufacturer of paper clips, many a DOT industrial fastener has had an equally revolutionary effect on modern fastening technique. Hundreds of different DOT fasteners have created relatively minor revolutions in specific industries.

A DOT fastener may save a few man-minutes of labor. It may save material. Or it may improve product performance and hence saleability. But multiply each small improvement by the units in a true mass-production operation and the savings really pile up to impressive proportions.

Rather than spend your own design staff's time on fastening problems, it might pay you well to call in DOT. You'll have at your service a design and production organization with large-scale facilities for genuine mass-production of special-purpose fasteners and self-fastening devices of all kinds.

Supplementing the Carr Fastener Company are a number of other plants which form the United-Carr Fastener group. They are located in the principal production centers of the United States, Canada, England and Australia. Your nearest United-Carr field office (see below) is no further away than a telephone call from your desk.

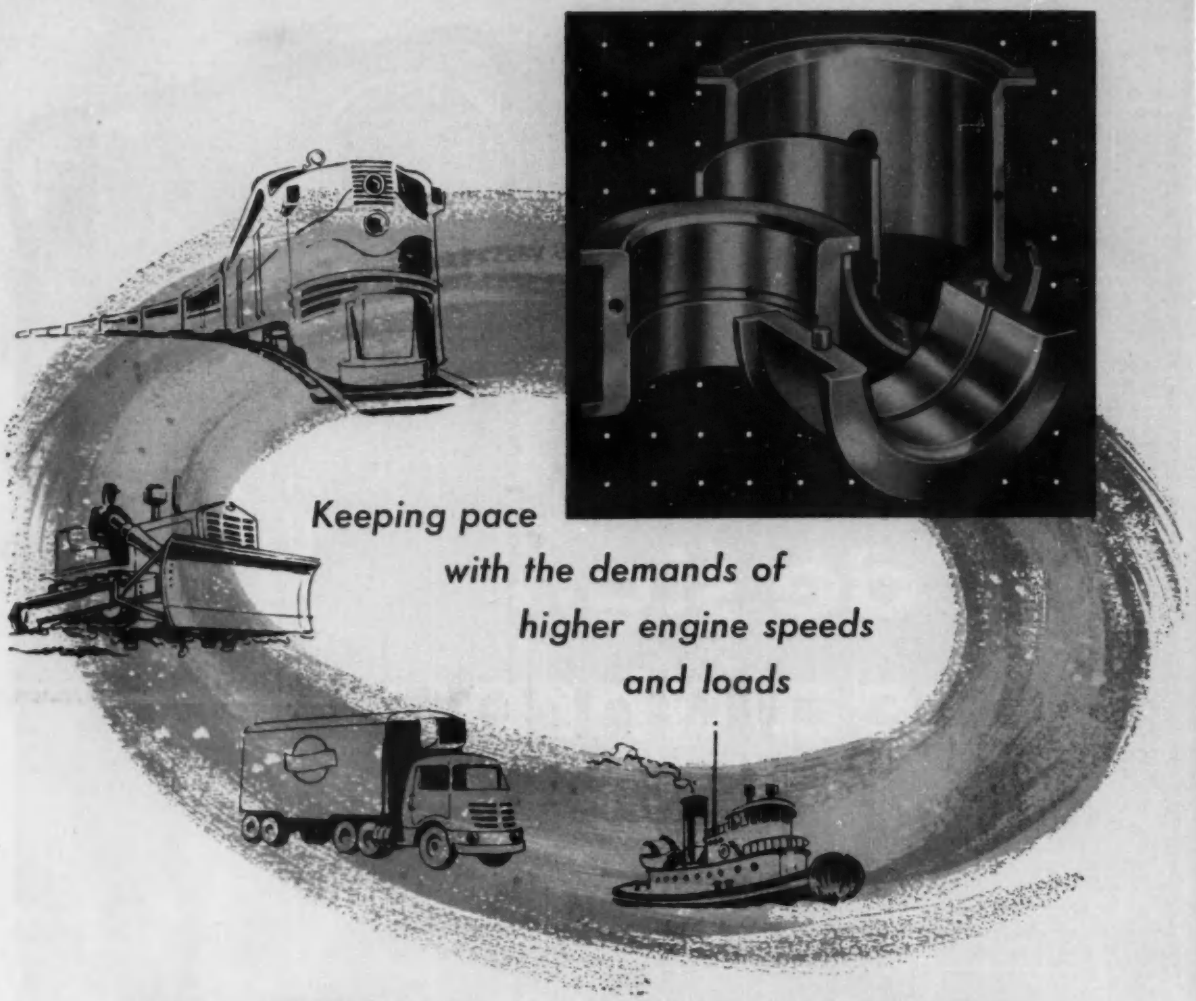
MAKERS OF DOT FASTENERS

CARR FASTENER COMPANY

Division of UNITED-CARR Fastener Corp., Cambridge 42, Mass.

Offices In:

Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Los Angeles, New York, Philadelphia, Syracuse



Johnson Solid Aluminum and Aluminum-On-Steel Bearings

For better performance, and to meet the demands of engine manufacturers, Johnson Bronze pioneered the development of solid aluminum and aluminum-on-steel bearings.

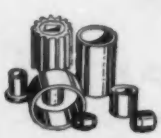
Solid aluminum bearings carry loads up to 4000 psi, and aluminum-on-steel to 6000 psi. These bearings have excellent embeddability properties, are ductile enough to conform to slight misalignments, and have high resistance to acid formation and attack by additive oils.

Johnson aluminum bearings are available in a wide range of plain or flanged, full or half bearings, with or without precision overlay. Take advantage of our years of experience in aluminum bearing design and production—your Johnson representative will be glad to work with you in improving the performance of your engines.

Johnson Bronze

675 South Mill Street • New Castle, Pa.
Subsidiary: Apex Bronze Foundry Co., Oakland, Cal.

JOHNSON Bearings


POWDER METALLURGY—BRONZE OR IRON

ALUMINUM ON STEEL SOLID ALUMINUM

BRONZE ON STEEL

STEEL AND BABBITT

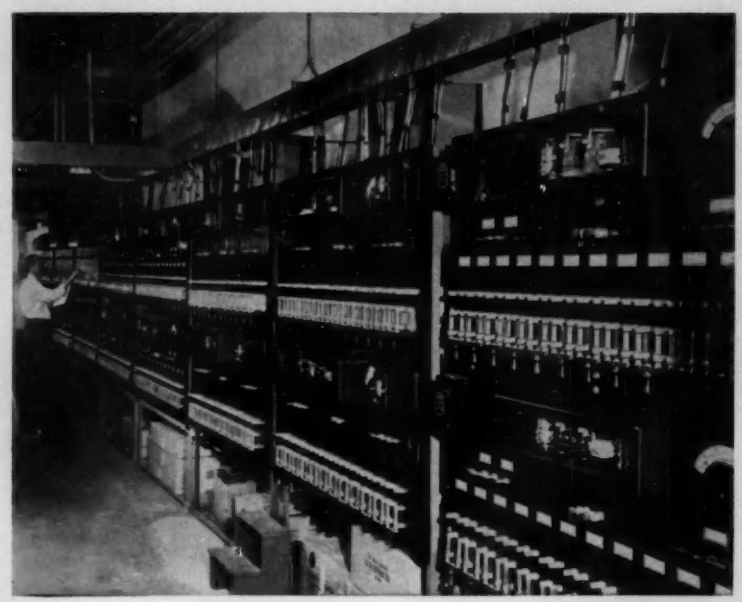
GRAPHITED BRONZE

BRONZE—CAST OR ROLLED

to GLOBE RESEARCH no battery is ever perfect

from Globe Research

regular battery examinations assuring long life and rated power



Periodic laboratory testing is a *must* if strict quality control of batteries is to be maintained. Globe answers this requirement with the industry's most intensive testing program — batteries taken from the production line at 16 plants undergo all of the SAE tests to guarantee meeting all standards.

Globe tests a minimum of 15,000 batteries annually at their Milwaukee facilities. These same rigid tests are also conducted on experimental and competitive batteries.

It is this continuing program of quality control that makes Globe Spinning Power Batteries unsurpassed in quality for either original equipment or replacement. Write today for more information on the battery that's right from the start.

PULSE TAKER

Trained Globe technicians test production batteries on SAE cycle life test machine. Checks such as this assure delivery of rated starting power and warranted life.

ANATOMY OF A BATTERY

After SAE tests, Globe specialists perform "autopsies" on dead batteries to determine cause of failure. Separators, grids and plates are examined; active material is weighed; measurements are taken of grid sections to ascertain extent of grid corrosion.

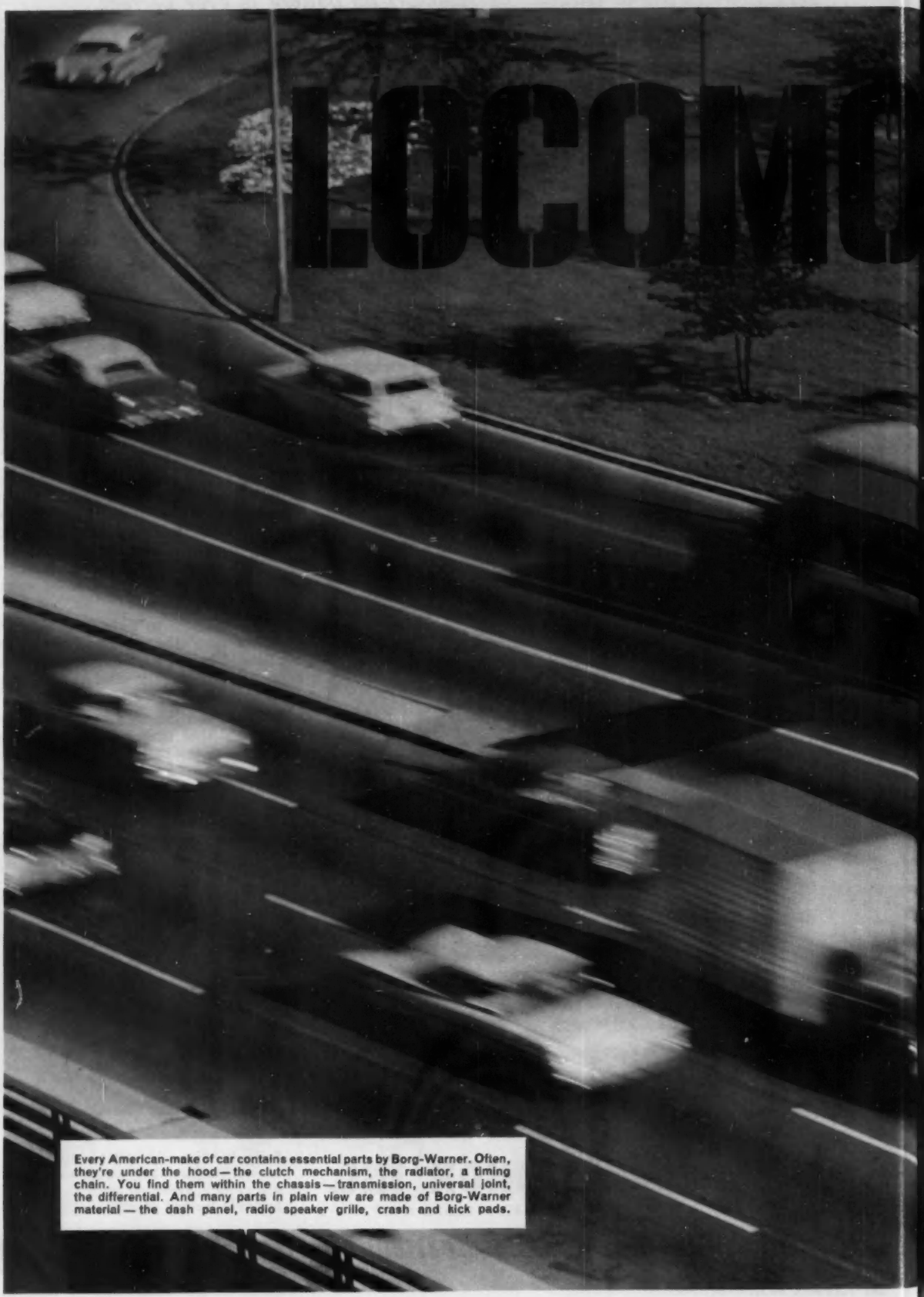
SPINNING POWER GLOBE-UNION SPLIT-SECOND STARTING

GLOBE-UNION INC.

MILWAUKEE 1, WISCONSIN

For original equipment or replacement Globe Spinning Power Batteries are readily available from 16 strategically located plants.

If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!



Every American-make of car contains essential parts by Borg-Warner. Often, they're under the hood — the clutch mechanism, the radiator, a timing chain. You find them within the chassis — transmission, universal joint, the differential. And many parts in plain view are made of Borg-Warner material — the dash panel, radio speaker grille, crash and kick pads.

TION
BY BORG-WARNER

A revealing look at the many ways in which a vigorous corporation helps you get from place to place

Ours is a nation of over 80 million vehicles—everything from automobiles to ambulances, from taxis to tractors, from cross-town busses to cross-country trucks. And Borg-Warner Corporation makes parts that help keep these wheels rolling.

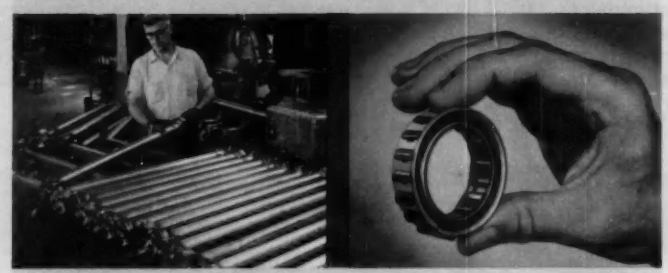
Take the automobile. We've been working hand-in-hand with the manufacturers of cars since the running-board era. Over the years, our search for better automotive components has produced exactly that—like the first standard transmission and an improved automatic transmission, development of a universal joint and a spin-resistant differential. Today, we're busy researching still better products into reality —for the models of '62, '66, '70.

Every Borg-Warner part that goes into an automobile is, in itself, quite a remarkable piece of machinery —and it's made of *more* than metal. In Detroit, Flint and Lansing and in Kenosha and South Bend, carmakers know that Borg-Warner delivers parts with built-in *quality*.

Borg-Warner Corporation contributes to far more than the automotive industry alone. We supply parts to the aviation and oil industries. We make industrial machinery, farm equipment and products for the home. We're deeply involved in national defense. And, in each area of Borg-Warner's activity, *you and your family* are the final beneficiaries.

OFF AN ASSEMBLY LINE at the Warner Gear Division plant come automatic transmissions which, by action of your fingertip, transmit power from engine to axle.

SMOOTH OPERATION of engine depends on a perfectly balanced clutch —assured in a Borg & Beck Division clutch by tests on this sensitive, specially designed machine.



READY FOR SHIPMENT by Mechanics Universal Joint Division: drive shafts and universal joints with fewer parts for easier assembly and service.

TINY AS IT IS, the Spring Division's full-phasing one-way sprag clutch is vital to the smooth, reliable performance of a modern automatic transmission.

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FLUID TORQUE CONVERTER, built with the superior engineering of Long Manufacturing Division, delivers a smooth flow of power from the very instant of acceleration.

OTHER DIVISIONS AND SUBSIDIARIES serving the automotive industry: Borg & Beck do Brasil, S.A. • Borg-Warner Ltd. (England) • Borg-Warner (Australia) Ltd. • Calumet Steel • Franklin Steel • Ingersoll Products • Ingersoll Steel • Long Manufacturing Company Ltd. (Canada) • Marbon Chemical • Marvel-Schebler Products • Morse Chain Company • Morse Chain of Canada Ltd. • Warner Automotive • Warner Gear Company Ltd. (Canada) • York

WHAT BORG-WARNER MEANS TO YOU!

Behind the wheel or beside the driver? City boulevard or country highway? Commuting to work or vacation-bound? Mechanical-minded or not? You experience the joy of a comfortable ride, the anticipation of a safe journey, the assurance of dependable and responsive machinery—thanks, in part, to essential automotive products made by the divisions and subsidiaries of Borg-Warner Corporation.

B-W

BORG-WARNER

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It's a better product when Borg-Warner makes it

For your specialized adhesive problems, call on Ray-BOND adhesive specialists

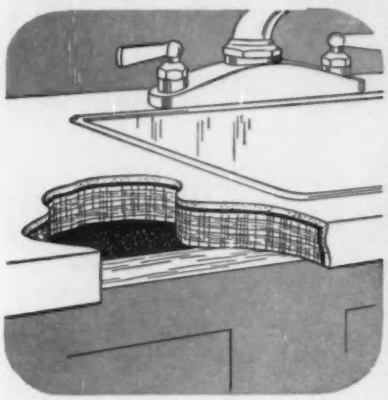
FOR THESE AND 1001 OTHER APPLICATIONS, NEW R/M RAY-BOND ADHESIVES CAN BE TAILORED TO YOUR NEEDS

Many of your fabrication and assembly problems can be solved quickly and economically with the wide range of Ray-BOND thermosetting and thermoplastic adhesives manufactured by Raybestos-Manhattan. For special requirements, R/M will tailor special adhesives . . . designed to meet your own particular manufacturing techniques, the demands of the materials you are using, and the service conditions of the product itself.

Whichever you use, you can be sure that Ray-BOND will help you cut expenses, speed production, and simplify your operations. You can assemble complex shapes, bond parts of dissimilar materials, and do away with rivets and other fasteners. Your products will be able to withstand extremes of heat and cold and will have greater conductivity.

If bonding, laminating, sealing or coating can cut costs or improve production in your own operations, call on Raybestos-Manhattan engineers today.

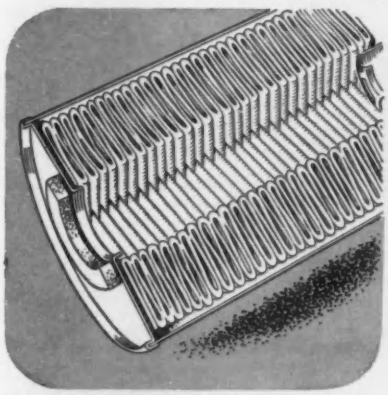
R/M Bulletin No. 700 contains engineering information you will want on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.



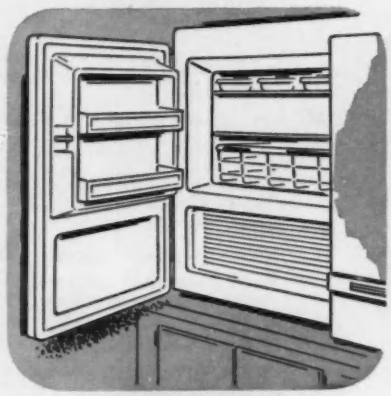
Bonding cabinet top to base.

To create a firm bond on polyethylene plastic sewer and irrigation pipe.

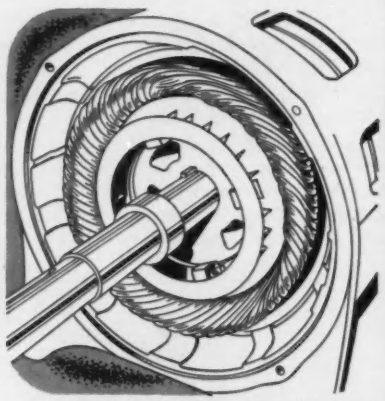
Bonding friction materials to metal.



Bonding paper to cork, aluminum or other metals for use in oil filter.



Bonding laminated panels of new plastic refrigerator.



Adhesives keep armature coil windings in place under severe operating conditions.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT: Bridgeport, Conn.

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FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Paramount, Calif. Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

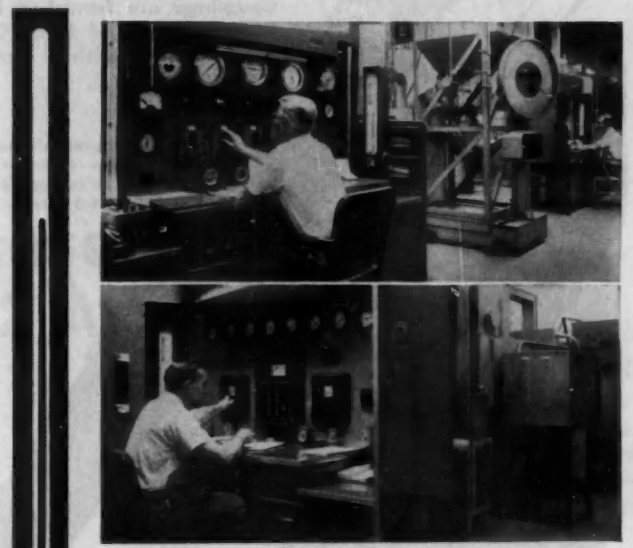
RAYBESTOS-MANHATTAN, INC., Industrial Adhesives • Brake Linings • Brake Blocks • Clutch Facings • Industrial Rubber • Engineered Plastics • Sintered Metal Products Rubber Covered Equipment • Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls

General Motors Reliability in Action...

HARRISON OIL COOLERS...RIGHT FOR THE ROAD...

BECAUSE THEY'RE *Performance-Tested* IN THE LAB!

The proof is in the testing! Harrison transmission oil coolers give maximum performance on the road, because they're *thoroughly* researched and performance-tested in the laboratory. Harrison-General Motors engineering and test facilities are complete, extensive . . . designed to lead the way to the best product possible for today's drivers. And GM's constant search for improvement is your assurance that Harrison temperature-control equipment will continue to set the pace for the tops in product reliability and value. If you have a heating or cooling problem, take advantage of a half century of experience in the automotive heat-transfer field! Look to Harrison for the answer.



A corner of the Harrison dissipator lab . . . where the heat dissipating characteristics of Harrison temperature-control products are measured and analyzed.

GM HARRISON

TEMPERATURES MADE TO ORDER

AUTOMOTIVE RADIATORS • OIL COOLERS • THERMOSTATS • AIR CONDITIONERS • HEATERS • DEFROSTERS

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK

2 NEW! STRATOFLEX HYDRAULIC COUPLINGS

Thanks to non-metallic seals, the new Stratoflex all-purpose couplings guarantee a positive self-sealing unit when connected or disconnected. When the two halves are connected, the valves open automatically to assure maximum flow, with a minimum of pressure drop.

Stratoflex Self-Sealing Couplings are available in three designs: wing nut, hex nut and knurl sleeve, with NPTF Pipe Thread or SAE "O"-Ring Boss Thread, in sizes ranging from ¼" to 1¼".

Stratoflex Quick-Disconnect Couplings are furnished in NPTF Pipe Thread and SAE "O"-Ring Boss Thread, with a size range from ¼" to 1".

For complete information on Stratoflex Hydraulic Couplings, write for Stratoflex Bulletin 5-6 immediately.

SF8-9

STRATOFLEX Inc.

P.O. Box 10388 Fort Worth, Texas
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto
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Fort Worth, Hawthorne
Houston, Kansas City
Milwaukee, New York
Philadelphia, Pittsburgh
San Francisco, Seattle
Toronto, Tulsa

continued from p. 138

is to summarize results of their cooperative work and submit this information to appropriate SAE and ASAE technical committees for review and consideration as standards or recommended practices.

Projects now under way include:

(1) *Development of an improved hitch connection between the tractor and implement.* The FEI Advisory Engineering Subcommittee on PTO Drives recently established goals for the development of an improved hitch connection between implement and tractor. The following are based on a study of approximately 60 common implement and tractor combinations:

- Reduce or, if possible, eliminate lost motion between the tractor and towed implement at the hitch pin.
- Provide for the amount of angular misalignment needed at the hitch pin to accommodate field operating conditions.
- Provide for quicker and easier attachment of the implement to the tractor than is prevalent with tractors and implements conforming to existing standards.
- Provide for tractors of one make to attach readily to implements of another make, but at the same time, avoid restrictive specifications that would prevent freedom of the individual manufacturers in developing latching mechanisms.

(2) *An improvement in fastening for the forward universal joint to the tractor PTO shaft.* The goals for this program are:

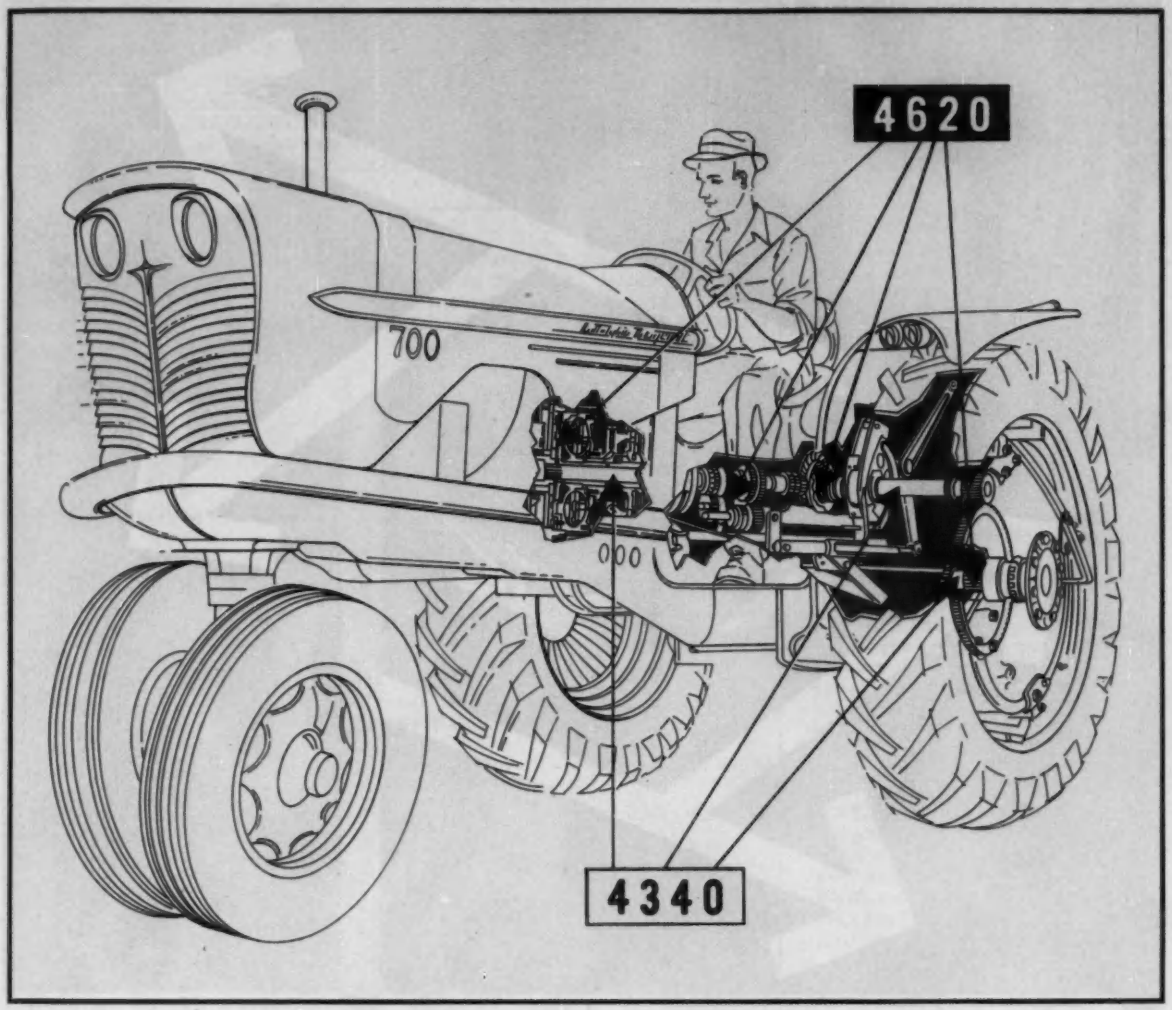
- An improvement in the durability of the means used to lock the knuckle on the tractor PTO shaft.
- Provision for attaching and detaching the forward universal joint to and from the tractor PTO shaft with less physical effort.
- Change the outside shape of the joint to reduce the tendency for clothing and like material to catch and wrap around the drive shaft.

(3) *Develop a standard that covers the PTO drive shaft assembly between the tractor and implement.* The FEI Subcommittee recommends the following:

- Concentrate on PTO drive shafts applicable to 1000-rpm implements.
- Consider the possibility of setting up a PTO drive shaft standard for 1000-rpm implements. The standard, if accepted by industry, would allow these implements to be sold without a PTO drive shaft assembly. A suitable PTO assembly for each size of tractor might then be furnished as a special equipment item in much the same way that hydraulic remote cylinders are now handled.

(4) *The 1000-Rpm PTO Program.* The new SAE-ASAE 1000-Rpm PTO Standard is now being disseminated to industry. It is expected that additional machines conforming to this standard will be introduced soon.

To Order Paper No. 95T . . . on which this article is based, see p. 6.



All these parts with just 2 Alloy Steels

Unique properties of 4340 and 4620 General Purpose Steels give you the opportunity to standardize, simplify, and save money . . .

These two General Purpose alloy steels can solve most of your steel selection problems. One a carburizing type, the other a through-hardening type – with just these two grades you can satisfy practically all your alloy steel requirements.

Here's your chance to standardize materials. To simplify inventory and processing. To save money in purchasing, inventory, production . . .

When you need through-hardening steel, simply specify 4340. It's ideal for parts of any section size. It provides exceptionally high strength and toughness. Responds reliably to heat treatment. It's weldable under proper conditions and machines at relatively high hardness.

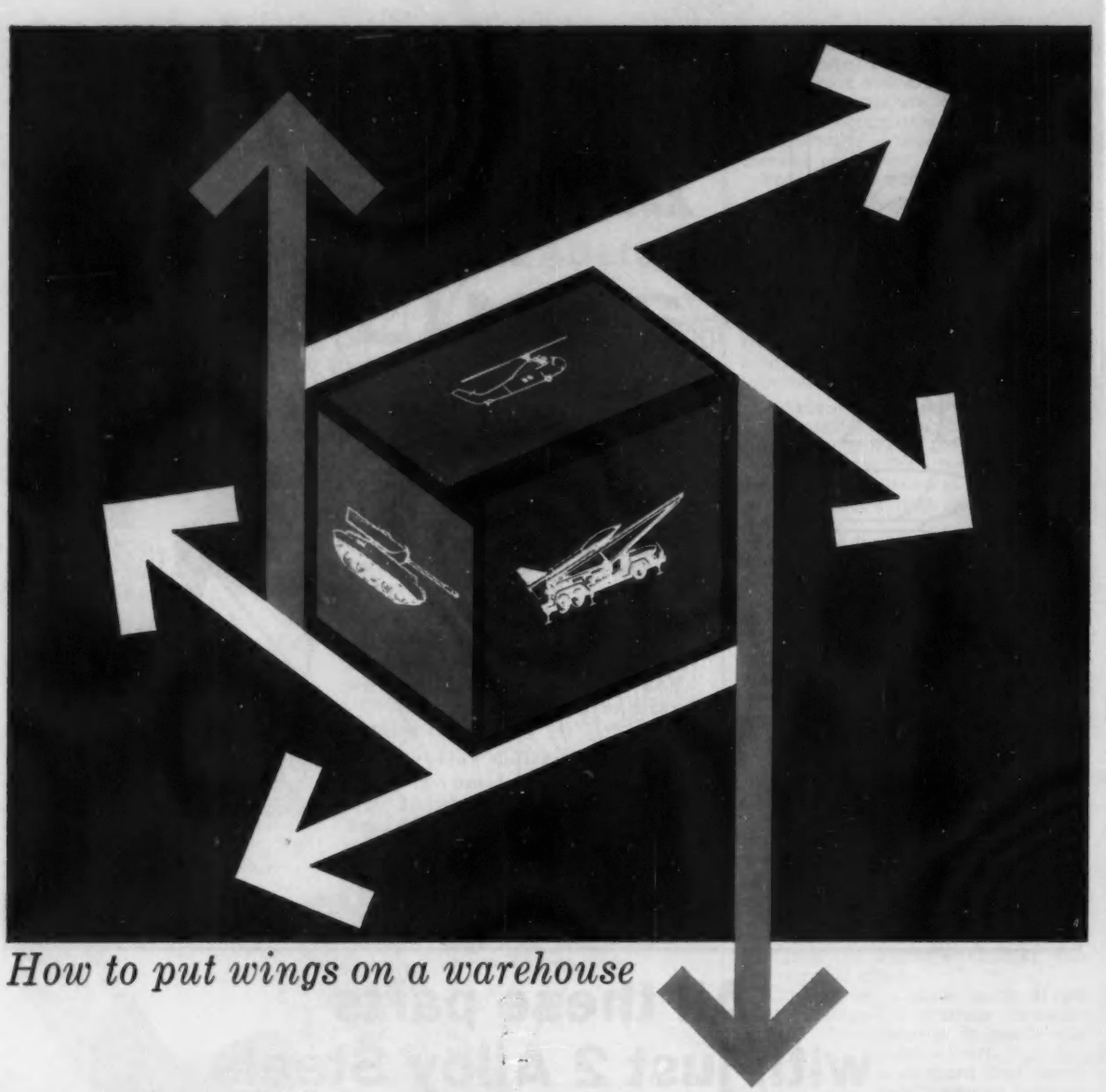
And when you need a carburizing steel, simply specify 4620. It resists warpage and distortion in heat treatment. Responds reliably and uniformly, too. Provides a tough, strong core to support the hard, wear-resisting case.

Best of all, both are carried by Steel Service Centers from coast to coast, ready for delivery right off the shelf. If you need steels with more specialized properties for very particular applications, suitable nickel alloy steels are also available from your Steel Service Center. A buyer's guide of centers that carry 4340, 4620, and other grades of nickel alloy steel, is yours for the asking.

AMERICAN STEEL WAREHOUSE ASS'N.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK



How to put wings on a warehouse

Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Some are listed on the facing page.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of DOUGLAS

JETLINERS ■ MILITARY AIRCRAFT ■ CARGO TRANSPORTS ■ MISSILE SYSTEMS ■ SPACE SYSTEMS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

New Members Qualified

These applicants qualified for admission to the Society between September 10, 1959 and October 10, 1959. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Dennie William Anderson (A), Dennis Keith McJunkin (J), Stanley E. Stauffer (A).

Baltimore Section

Wm. M. Schell (J).

British Columbia Section

Ronald Buckoll (A), George Edward Johnston (A).

Buffalo Section

John J. Hanrahan (J), Lloyd A. Molby (J).

Central Illinois Section

Alfred L. Baccheschi (A), Keith E. Koch (M), James A. MacLean (M), Frederick W. Pfeiffer (J), Rex Piha (J), David Scott Ullman (J), Donald J. Waugh (A).

Chicago Section

Thomas Atkin Brandon, Jr. (J), Fred Joseph Collinet, Jr. (M), Richard F. DeThorne (J), Robert Alan Green (A), James George Kapoulas (M), Ernest L. Kirshtner (M), Thomas L. Kmieciak (M), Carl E. Overton (M), Carl E. Rudolph (M), Frank J. Stefanov (M), John J. Witczak (A), Granville Woolman (M), Virgil R. Yoder (A).

Cleveland Section

Douglas Harold Birch (M), Warren E. Boudrie (J), Milburn K. Carey (A), William C. Douglas (J), James Bayard Foulk (J), Edmund Joseph Fuchs (M), Frank Herzegh (M), Leland C. Hunt (A), Edward Emri Kish, Jr. (J), Bernard A. Kuhl (M), John W. Little (A), Fred L. Main (M), James Dennis McCabe (J), Fred T. Perkes (M), Bradley A. Pritts (M), John J. Sherlock (M), Carl F. Simon, Jr. (M), James Paul Tompkins (M), Lewis J. Valentine (J), Ellis Mickle Wellman (J), Kendall C. White (M).

Dayton Section

Donald Eugene Brammer (J), Wayne A. Karlgaard (M), Robert J. Riner (J).

Detroit Section

Richard E. Allen (J), Lionel J. Bedells (A), William G. Billmeier (J), Richard Reinhold Born (J), Robert M. Burch (M), Frederick A. Burne (J), Douglas Richard Dixon (J), Gerald J. Dorcey (J), Robert L. Filbert (J), Roy Adolf Gelpke (J), Fred V. Gieryn (M), George E. Hamlin, Jr. (J), Alan D. Hayes (J), Robert John Hoffmann (M), August J. Hofweber (M), Walter P. Hopfner (J), William A. Houk (M), Albert M. LaRou (M), Lynn A. Martin (J), Bernard G. Mazurek, Jr. (J), John W. McDonald (M), John L. Metevier (A), Franklin A. Miller (A), Vincent H. Oliver (A), Lawrence E. Pulkownik (M), Roy H. Robinson (J), Donald Leo Roskopf (J), Walter Ruddy (M), Robert G. Simpson (J), Arthur F. Tarabusi (A), Walter Edward Tutak (J), Dale A. Van Deven (J), Earl N. Verbridge (A), Clark R. West (J), Ralph C. West (J), Edward Frank Wiecha (J), Edward G. Zwiller (A).

Fort Wayne Section

Harvey C. Habegger (M), Anthony Kleis (J), Dean P. Stanley (J).

Indiana Section

Luis Chong-Leon (J), William Julian Keller (M), Carl W. Pettit (M), Gerald M. Ridgeway (J).

Metropolitan Section

Joachim Aue (M), Hartley W. Barclay (M), Murray Benett (M), Carl Carvell (J), Oscar O. Cote (M), Kenneth J. Dahms (M), James Edmund Erickson (J), Lawrence W. Fagel (J), Fred B. Fischl (M), George N. Freund (J), B. L. Groser (A), John C. Harvey, Jr. (A), Stephen Katzko (M), R. A. Keckeissen (A), Christopher Robert Landmann (M), Edward L. McCandless (M), William T. J. Oliphant (M), John K. Patterson (M), James Karlsen Sorgini (M), Thomas J. Stokes (M), Raymond Warell (J).

Mid-Continent Section

Don E. Lewis (J), Charles B. Miller (M), Melvin E. Putnam (M), Roger W. Sackett (J).

Mid-Michigan Section

Joseph F. Doerr (A), Robert C. Kerchner (J), Dennis Milton Manner (J), Ronald J. Sargent (J), Ralph E. Towne (M).

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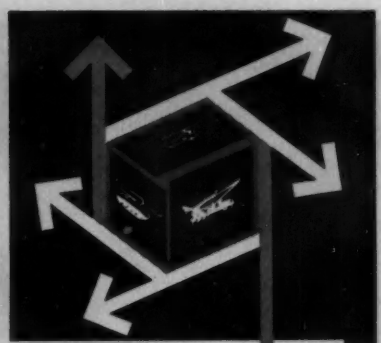

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DOUGLAS AIRCRAFT COMPANY
MISSILES AND SPACE SYSTEMS

has immediate openings in the following fields—

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Control System Analysis & Design
Antenna & Radome Design
Radar System Analysis and Design
Instrumentation
Equipment Installation
Test Procedures
Logic Design
Power System Design

Mechanical Engineering—
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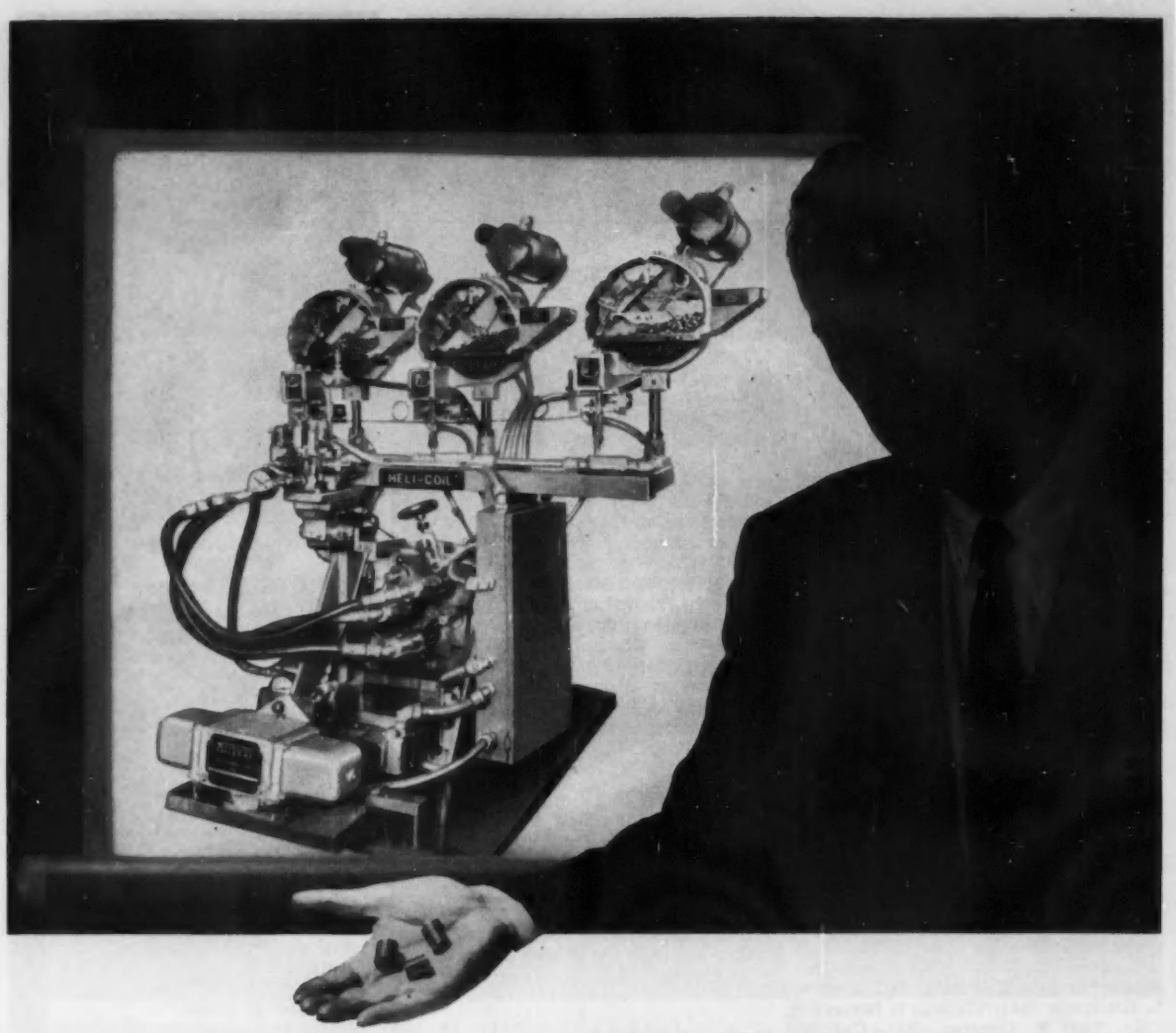
Servo Units
Hydraulic Power Systems
Air Conditioning Systems
Missile Launcher Systems
Propulsion Units and Systems
Auxiliary Power Supplies

Aeronautical Engineering:
Aerodynamic Design
Advanced Aerodynamic Study
Aerodynamic Heating
Structural Analysis
Strength Testing
Dynamic Analysis of Flutter and Vibration
Aeroelasticity
Design of Complex Structure
Trajectory Analysis
Space Mechanics
Welding
Metallurgy

Physics and Mathematics:
Experimental Thermodynamics
General Advanced Analysis in all fields
Computer Application Analysis
Computer Programming and Analysis
Mathematical Analysis

For full information write to:

Mr. C. C. LaVene
Box 620-O
Douglas Aircraft Company, Inc.
Santa Monica, Calif.



"Automatically installed, these Heli-Coil® Screw-Thread Inserts give Ford aluminum housings permanent steel threads."

Automatic, high-speed machines are installing these ***Heli-Coil*** steel wire thread inserts on Ford production lines right now. Designed and built by ***Heli-Coil*** engineers, they automatically position and install three inserts in an aluminum transmission housing in seconds.

Heli-Coil **Inserts** give aluminum threads the strength of steel for the life of the unit. Without them, tapped holes in the starter mounting pad would have been too soft to resist wear under vibration, impact and occasional removals of the starter for service.

Use of ***Heli-Coil*** steel inserts opens up new design possibilities for your light metal assemblies — and automatic equipment can be built to meet your exact requirements! Here's what ***Heli-Coil*** Inserts will do for you —

- hold screws or studs secure under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing even in soft metals
- allow repeated assembly and disassembly without loss of thread strength
- permit use in standard proportion bosses without need for redesign
- can be specified for a complete range of U.N.C. and U.N.F. thread sizes as well as spark plug and pipe thread series
- save assembly time, space, weight and cost

For complete design data on Heli-Coil Screw-Thread Inserts, clip and mail the coupon.

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION
3611 Shelter Rock Lane, Danbury, Conn.

Send complete design data on *Heli-Coil* Screw-Thread Inserts

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ADDRESS_____

CITY_____ ZONE___ STATE_____ 1592

New Members Qualified

continued

Milwaukee Section

James Cantwell Adamson (J), Eugene M. Hermansen (J), Frederick Carlton Klaus (J).

Mohawk-Hudson Section

Charles M. Chodash (J), John H. Rogers (M).

Montreal Section

Andre Gagne (J), (Rosscoe) Grant McCarthy (J), Lee M. Yarberry (M).

New England Section

Ralph F. Cataldo (M), Seth Gibson (J), Frank E. Harlow (M), Robert G. Kitson (A).

Northern California Section

Tipton A. Gilbert (J), Robert W. Goode (M), Kent B. Kitterman (J), Frank W. LaHaye (M), Robert David Swanstrom (J), Edward Masao Takemori (J), Jack A. Wahle (M).

Northwest Section

William Fred Anderson (J), Thomas J. Dean (A).

Ontario Section

William E. Algie (A), Ralph Warren Biggar (A), Ronald Lee Greenough (J), Gordon Edward Grundy (A), William Frederick McAvoy (A), M. Bruce Selman (M), Richard Henry Syson (M).

Oregon Section

Dale Malvin Ott (J), Thomas A. (AL) Rice (A).

Philadelphia Section

Edwin S. Braun (A), Robert M. Cytron (J), Joseph Field (M), William C. Hart (M), Elliot J. Parker (M), Walter S. Ray (J).

Pittsburgh Section

J. Carl Mulac, Jr. (J).

Rockford-Beloit Section

Frederick A. Simmons (A), Einar Swedberg (M).

St. Louis Section

Albert Edward Cawns (J), Jerald Edwin Drewel (J), Leonard B. Graiff (J), Joseph Walter Hradsky (J), Arthur L. Roux (M), Earl L. Will (M).

Salt Lake Group

Charles C. Burres (A), Richard G. Laucher (M).

continued on p. 152

GAS • OIL • ELECTRIC • DIRECT FIRED OR ATMOSPHERE CONTROLLED

Production Heat Treating Equipment

FOR ANY OF THESE PROCESSES:

ANNEALING • BRAZING • CARBURIZING
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FORGING • HARDENING • SINTERING
NORMALLIZING • TEMPERING

43 Years Of Engineering Leadership

WORKING WITH THESE MATERIALS:
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Malleable • Stainless • Steel

OF ANY OF THESE TYPES
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Shaker Hearth • Roller Type • Walking Beam

HOLCROFT & COMPANY

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TYLER 4-5700

New Members Qualified

continued

San Diego Section

Robert P. Dodds (M), Leroy Archie Hughes (J), Warren Lyle Rath, Jr. (A), Richard A. Schneeloch (M), Charles F. Warner (J), Floyd E. Zimmerman (M).

South Texas Group

John A. Buster, Jr. (A).

Southern California Section

C. V. Bennett (A), David Ray Cook (J), Thomas H. Elkins (J), Thomas V. Jones (M), Anthony Richard Lamb (J), James McDonald (M), Cecil Joseph Paoletti (J), John Lee Rogers (J), Mitchell Harvey Seidman (J), William Duncan Stewart (M).

Southern New England Section

Richard S. Juralewicz (J).

Texas Section

Alfred Paul Brandimarte (M), Fred C. Ruth, Jr. (A), Willis J. Taylor (M).

Texas Gulf Coast Section

Robert H. Hurd (M), Dan W. McCants (A).

Twin City Section

Merrill Allyn Johnson (J), Edward Lyle Smith (J).

Washington Section

W. H. Leathers, Jr. (M), Ronald Alan Munier (J).

Western Michigan Section

Charles E. Barnum (J), Russell E. Cribbs (J), Henry S. Elliott (M), Clement E. Naperala (A), Gordon E. Reynolds (M), Lee H. Saylor (J).

Williamsport Group

John T. Gibson (A), William E. Long (A).

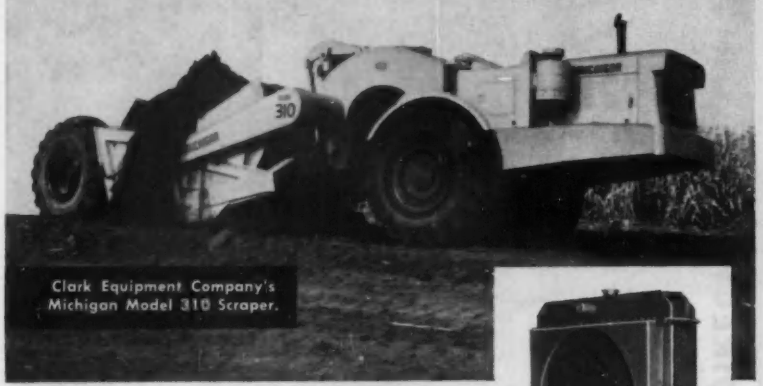
Outside Section Territory

James Sidney Freers (J), Malcolm J. Hahn (A), M. F. Marti (M), John P. Mentink (M), Wm. Joseph Preising (M), Robert E. Rockefeller (M), Carl R. Scheuplein (M), Wilhelm E. A. Schmidt (M), Richard Allen Wise (J).

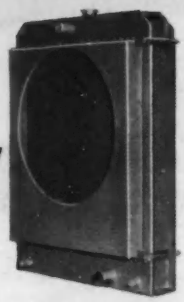
Foreign

A. V. J. Fernandes (M), India; Tharavath Madhavan Kutty (J), India; Gunter Wilhlem Maybach (J), West Germany; James L. McVay (M), Argentina; Thomas Molnar (M), Australia; C. P. Parankusam (J), India; Paul Pinier (M), France; Werner K. Schmidt (M), West Germany; Arthur William Whitehouse (M), England.

Young designs special radiator with built-in oil cooler for Huge New Tractor-Scraper



Clark Equipment Company's Michigan Model 310 Scraper.



Rear view of radiator shows connections for oil cooling.

MONO-WELD® Radiator by **Young**

Cools both water and oil under toughest operating conditions

Cooling giants like this Michigan Model 310 scraper is a job calling for Young radiators. By designing a radiator with a special core section at the bottom equipped with patented turbulators for cooling the lube oil, Young eliminated the need for a separate oil cooler. Special construction features of the Mono-Weld Radiator insure maximum heat transfer and dependable ruggedness to match the superior construction of this equipment.

Young radiators are used where the going is tough

Write Dept. 119-L for catalog No. 148A

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

Applications Received

The applications for membership received between September 10, 1959 and October 10, 1959 are listed below.

Alberta Group

Donald Edward Deane, Ronald Clayton Tomlinson

Atlanta Section

James M. E. Akridge

Baltimore Section

Andrew S. Loboda

British Columbia Section

William Clarence Jones, James Victor Whitehead

continued on p. 155

600° to

HIGH STRENGTH AND STABILITY

1000° F.

WITH GOOD FABRICATION PROPERTIES

AM 350 and AM 355 are metals for the space age! The combination of easy fabrication with high strength-to-weight ratio of AM 350 and AM 355 interests missile and supersonic aircraft designers with problems of high strength at elevated temperatures.

This pair of precipitation hardening stainless steels from Allegheny Ludlum research are easy to fabricate in the annealed condition. They can be spun, drawn, formed, machined, brazed and welded using normal stainless procedures.

Both alloys have high strength without embrittlement from room temperature to 1000°F, plus good ductility at elevated temperatures. They have remarkable stability and excellent corrosion resistance.

AM 350 is available in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355," **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

822

ALLEGHENY LUDLUM

AL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

KNOW YOUR ALLOY STEELS...

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Heat-Treatment Affects Alloy Steels

Heat-treatment may be defined as an operation or series of operations involving the heating and cooling of steel in the solid state to develop the required properties. There are in general five different forms of heat-treatment used with alloy steel. These treatments modify the mechanical properties of the steel to suit the end use.

The five forms of treatment mentioned above, as applied to constructional alloy steels, are discussed in the following paragraphs:

(1) *Quenching and Tempering.* This form of heat-treatment usually consists of three successive operations: (a) heating the steel above the critical range, so that it approaches a uniform solid solution; (b) hardening the steel by quenching it in oil, water, brine, or salt; and (c) tempering the steel by reheating it to a point below the critical range in order to effect the proper combination of strength and ductility.

(2) *Normalizing.* A form of treatment in which the steel is heated to a predetermined temperature above the critical range, after which it is cooled to below the range in still air. The purpose of normalizing is to promote uniformity of structure and to alter mechanical properties.

(3) *Annealing.* This method consists of heating the steel to a point at or near the critical range, then cooling at a predetermined slow rate. Annealing is used to soften the steel, to improve machinability, to reduce stresses, to improve or restore ductility, and to modify other properties.

(4) *Spheroidize-Annealing.* This form of heat-treating requires prolonged heating of steel at an appropriate temperature, followed by slow cooling to produce a globular condition of the carbide. This treatment produces a structure which may be desirable for machining, cold-forming, or cold-drawing, or for the effect it will have on subsequent heat-treatment.

(5) *Stress-Relieving.* This is the process of reducing internal stresses by heating the steel to a temperature below the critical range, and holding for a time interval sufficient to equalize the temperature throughout the piece. The object of this treatment is to restore the elastic properties of the steel, or to reduce stresses that may have been induced by machining, cold-working, or welding.

Each of the five forms of heat-treatment will be the subject of a future advertisement.

Bethlehem metallurgists have had long experience in all methods of heat-treatment. They understand the possibilities and limitations of each method with respect to various alloy steels. These men will be glad to help you with any problems concerning heat-treatment. Feel free to ask for their services.

And call on Bethlehem, too, for the full range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades. We can meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Applications Received

continued

Buffalo Section

Duane R. Crumb, Gerard H. Hilbers, Harold G. Kern, Felix G. Masci, Albert J. O'Mara, Russell R. Roberts, Sheridan D. Smith

Central Illinois Section

Gail G. Avery, Donald Louis Bianchetta, Harold R. Bleigh, William Lee Brown, Jr., Ronald Eugene Dennis, Richard A. Elward, Robert D. Fischer, Harold J. Harp, Ralph B. Henson, Richard A. Kern, Earl M. Kerr, Daniel O. King, Ziedonis I. Krauja, Daniel Charles Lenkaitis, Kenneth Wm. Mettelmann, Charles R. Miller, Dean E. Miller, Elbert H. Miller, Donald Dean Necessary, Donald J. Waldman, Ronald Wintriss

Chicago Section

David G. Benson, Clarence J. Bohn, James H. Bornzin, Arthur W. Donkin, Donald W. Forsyth, Benjamin Friedman, Keith H. Fulmer, John J. Kunkel, Jr., Joseph A. Kwiatkowski, Darryl D. Moffatt, Duane L. Repp, Kenneth R. Robinson, Robert A. White, Joseph Charles Vruno

Cincinnati Section

Joe W. Savage

Cleveland Section

Joseph P. Balionis, Paul Allan Cirino, Thomas Robert Conway, Warren Ervin Fife, Michael E. Kastner, Morgan Martin, Walter F. Mog, Lee F. Schiemann, Chester F. Schwall, Jr., Samuel Leonard Slade, Jack P. Willard

Dayton Section

Von Dean Harrison, William V. Kenzik, Dale D. Steinke

Detroit Section

Thomas Francis Adams, Gordon C. Applequist, Eli H. Benstein, Herbert Charles Brodsky, Donald A. Brownson, Glenn L. Calcamuggio, Louis E. Calvin, Leo Cecchini, Dean M. Chisel, Stanley Wilson Crater, Wallace C. Donoghue, Edward G. Essad, Jerome T. Ficht, Guy W. Fitch, Walter V. Flood, Joseph R. Fortier, Theodore E. Guzanek, Jr., David E. Halkerston, John W. Harper, Duane Henry Harwick, James F. Hoffman, William George Huley, John Edwin James, Richard H. Jarmon, Rudolf Kaegi, J. Edward Kloian, Robert L. Kopf, Witold D. Kowalczewski, Arthur A. Kowalski, Robert Lee LeFevre, Robert Frederick Luther, Donald C. MacDonald, Joseph J. Magyar, Odell C. Mercer, Richard G. Mitchell, W. L. Mitchell, Boris P. Muchnij, Richard E. Muller, Randal Thomas Murphy, Norbert A. Nann, George Edward Nies, Philip Ellis Nimmo, III, Gary Osterbeck, Leonard J. Paciorek, John J. Pathe, Jr., Dennis P. Pazuk, Fred C. Porter, Charles D. Potter, John P. Price, Erwin G. Rapske, Arnold Keith Riddle, Gilbert H. Selke, Michael D. Sheean, William C. Sink, Donald Joseph Smithbauer, Lawrence P. Sullivan, Ernest D. Thompson, Christianus van der Zon, Lawrence Marvin Weathers, Richard A. Wilde, David Perry Williams, William B. Williams, David Ronald Wilson, William J. Wittenberg, Gerald A. Wooldridge

Fort Wayne Section

William R. Hall, Carl William Linder, Charles F. Powell, Jack A. Richardson, Bruce D. Sibley, Benjamin R. Vian

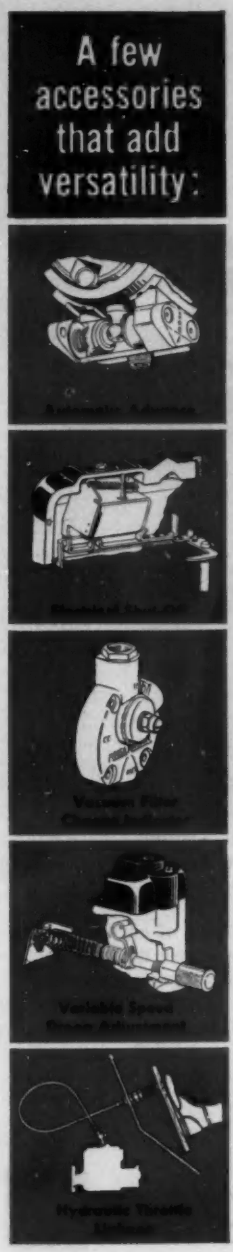
Hawaii Section

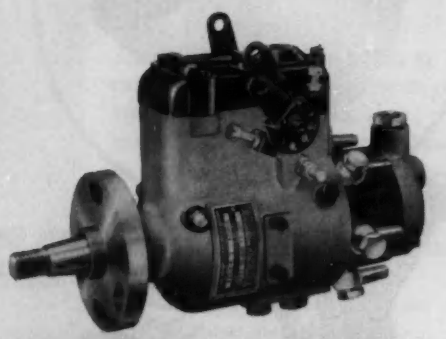
James M. Bailey

Indiana Section

Thomas Allen Berghoff, Brian Corrigan, Morris Eschw, Benjamin John Holanda, Merwyn R. Jacoby, William J. Keller, Jr., Edward John Newill,

continued on p. 156





ROOSA MASTER

Most Versatile

FUEL INJECTION PUMP

Diesel engine manufacturers, their designers and engineers are specifying ROOSA MASTER because they know that it is the most versatile. There are many reasons for selecting this pump. Here are just a few:

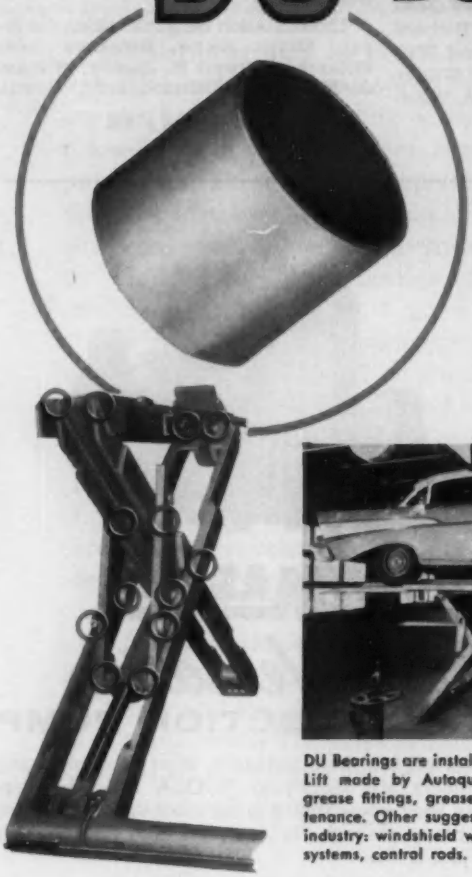
- **VERSATILE** because of the variety of built-in, space saving, accessories demanded by modern diesel engine design. Roosa Master can provide more compact, lower cost, complete units to meet many different applications.
- **VERSATILE** because only one size pump serves either a 2, 3, 4, 6, or 8 cylinder, 2 or 4 cycle, small or large displacement engine . . . and only Roosa Master can be mounted vertically or horizontally.
- **VERSATILE** because it is applicable to automotive, construction, farm, generator, marine and stationary equipment guaranteeing dependable, economical service. Write for further information.

HMS ROOSA MASTER makes good diesels better

HARTFORD MACHINE SCREW CO., HARTFORD 2, CONN.

DIVISION OF STANDARD SCREW COMPANY

New Glacier DU Bearings



". . . less than 1/6th the coefficient of friction we had previously achieved at 15,000 psi."

J. E. CLARKE, President
Autoquip Corporation

DU Bearings are installed at vital bearing locations on the Lift made by Autoquip Corp. DU eliminates need for grease fittings, grease grooves, grease guns—and maintenance. Other suggested applications of DU in the auto industry: windshield wipers, steering columns, suspension systems, control rods.

In search of a "permanent" or "dry" bearing for their Porta-Contact hydraulic lift, Autoquip engineers tested new Glacier DU bearing material. To their amazement, DU bearings had less than 1/6th the coefficient of friction of the best material previously tested. Under endurance runs, DU gave equal to three years' service without so much as a squeak. Now, after nearly one year of actual lift operation, not a single bearing problem has arisen!

DU is a patented composite material consisting of a steel-porous-bronze interlayer impregnated with a lead-filled TFE* fluorocarbon resin. It has greatest structural strength, heat conductivity, and thermal stability of any dry bearing . . . withstands temperatures from −328° F to +536° F.

Exhaustive testing of DU has permitted the establishment of curves relating bearing life to various load-speed combinations. Designers can quickly predict DU bearing life by referring to these curves—and other design data—found in Bulletin DU-458. Ask your bearing manufacturer about it, or write to SPECIAL PRODUCTS DEPT., United States Gasket Co., Camden 1, N. J.

United States Gasket

*Teflon, DuPont Trademark
Fluon, I.C.I. Trademark*

Plastics Division of GARLOCK

Applications Received

continued

Julius P. Perr, Keith G. Rochford, M. R. Williamson

Metropolitan Section

Paul Altmann, Peter Arthur Aron, W. E. Bangert, Robert H. Carlson, John G. Forbes, David Kaplan, William R. Klingler, Wolodymyr E. Kulynycz, Donald Drewry Love, Edward K. Matthews, William B. Miner, Howard D. Rubenstein, Armand A. Small, Richard G. Smith, Gilbert W. Speed, Adolf W. Strom

Mid-Continent Section

J. Vernon Lawson

Mid-Michigan Section

Harold M. Bergdolt, Roland John Fernekes, John Thomas Herridge, Richard W. Morris, Richard A. Murley, Larry Ruffle

Milwaukee Section

Hubert John Anderson, Richard T. Brandt, George H. Glum, Franklin H. Greb, Robert Anthony Hall, Wallace H. Hinz, Glen Hodel, Donald A. Miller, David H. Minshall, Thomas Harold Mohar, Thomas James Olk, Donald Joseph Pribyl, Robert B. Temple, Jr.

Montreal Section

Ronald Alfred Lennard

New England Section

Thomas Robert Egan

Northern California Section

Aksel Sigmund Holland, John F. Skinner, Everett Eugene Spitler, Gino R. Zepponi

Northwest Section

Eugene Robert Benner, Gerald Wayne Canada, Alfred W. Finch, Ronald McIrvin, Dean Musche, Leonard Schroeter

Ontario Section

George Stephen Bagosy, Barry Benson, John V. Berger, Michael J. Heuer, Bruce Lee Newman, George L. A. Palinkas, H. G. Ronson, Kenneth Jack Schwietz, John Thompson Sinclair, August Sunnen, Lloyd S. Tweedle, David H. Williamson, Fred S. Wood

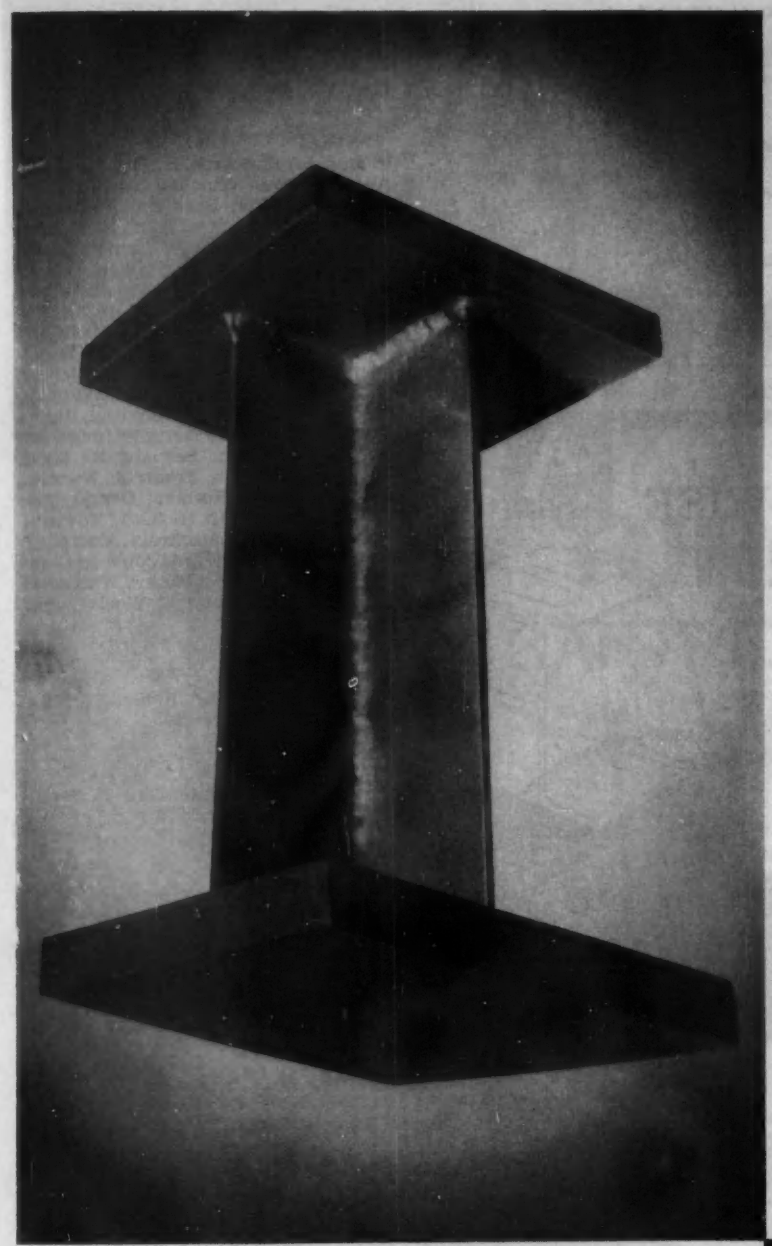
Oregon Section

Harlan David McKay

Philadelphia Section

Bernard Richard Bolstad, Harry Davis, Jr., Theodore R. Douglass, James A. Flint, III, James A. Heidamos, Robert B. Mackie, Robert R. Rossi, Anthony N. Schmitz, Hilbert L. Stevens,

continued on p. 158



ROHR

continues to pace industry in the field of metal structures. Current advanced programs are solving the problems of **economical application** of new and

PROGRESSIVE METALS

The ability of these materials to maintain structural integrity at great temperature ranges long ago earmarked them for important roles in high speed aircraft and space vehicle development.

By their very nature, however, they are expensive and difficult to handle. Rohr's concentration on putting these metals to work practically and economically is paying dividends to the aerospace industry. The swift new Lockheed JetStar, for example, will use Allegheny Ludlum's A-286 in linkage and support structures of its thrust reversers. Techniques in welding and machining are being steadily improved on such advanced alloys as H-11, General Electric's Rene' 41, and the more dramatic metals.

Test sample weldment of René 41 high-nickel alloy for research purposes.

Experienced engineers will find attractive openings within challenging commercial and military programs at Rohr.

WORLD'S LARGEST PRODUCER OF COMPONENTS FOR FLIGHT

ROHR AIRCRAFT CORPORATION

CHULA VISTA AND RIVERSIDE, CALIFORNIA

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continued

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Pittsburgh Section

Kenneth G. Brickner, Charles J. Cressman, Stewart F. Sonen

Rockford-Beloit Section

Alvin H. Anderson, Charles Earl Elliot, Rudolph C. Kozlik, Reginal E. Stanley, Roy A. Stone

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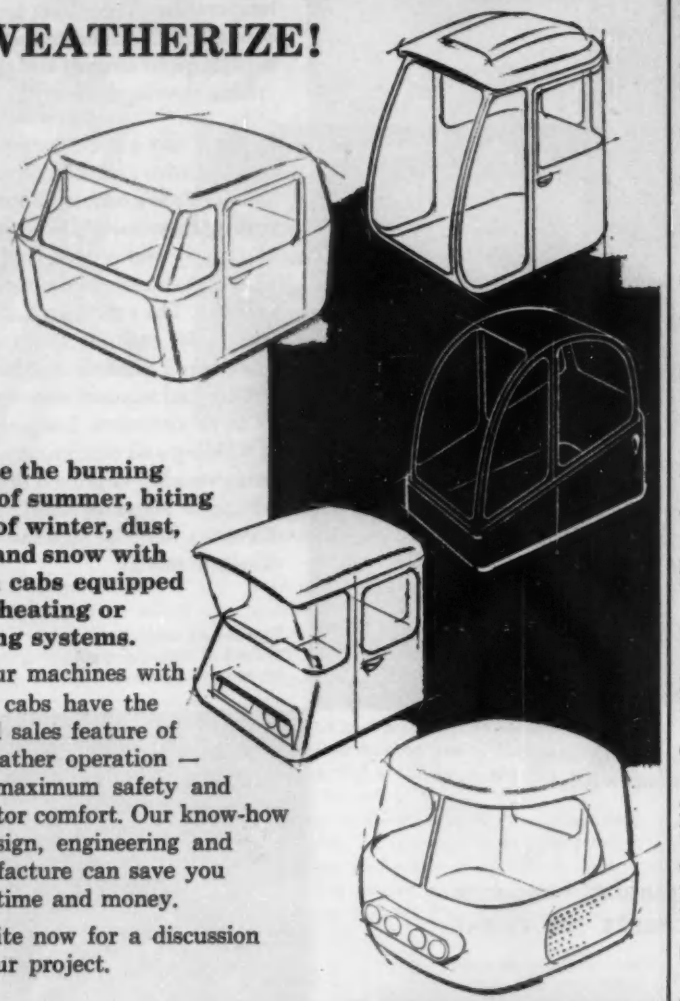
BE WEATHER-WISE
—WEATHERIZE!



Tame the burning heat of summer, biting cold of winter, dust, rain and snow with Allen cabs equipped with heating or cooling systems.

Your machines with Allen cabs have the added sales feature of all-weather operation — plus maximum safety and operator comfort. Our know-how in design, engineering and manufacture can save you both time and money.

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Fred Arrence Ahle, H. Richard Alexander, James Winchell Atwater, Jr., Frank S. Baker, Burnham R. Benner, Gene Charles Bessolo, David H. Bienert, Aaron Bloom, Lewis William Bugenig, Donald Robert Buist, Wallace A. Burton, Alvin P. Cluster, James DeKlotz, John S. Fitzpatrick, John Andrew Ganger, Raymond M. Hamada, Ernest Theadore Hillberg, William Hill Huntington, Manly Ernest Johnson, Richard C. Keidel, William V. Lanphar, Edward B. Lee, William Bruce Lindsay, James Norman Locke, Vincent G. Magorien, James C. Martin, Bernard N. Maas, Lloyd F. Mauldin, Frank J. Norman, William Joseph Rozinka, Dennis Patrick Ryan, Warren H. Sack, Edwin J. Sarge, Henry A. Smolinski, Darrell F. Theige, Gene R. Ward, John Anthony Wentworth, William Robert Whittaker, John P. Wiley, John E. Woelke, Jack P. Wright

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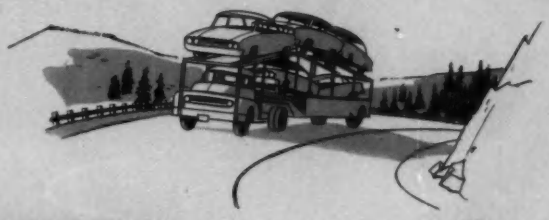
Philip K. Davis, Paul A. Gilliland, L. L. Nighswonger, Jerome D. Rader, Henry J. Thomas

Outside of Section Territory

Roland Roy Armstrong, John Walter Arnold, Robert Eric Beveridge, Walter B. Clement, Bernard Maurice DeMarr, William Thomas Fouser, Jr., John Joseph Fox, Herbert Arthur Jespersen, Joseph E. Link, Wayne Louis Peterson, Paul R. Smargiassi, Myron S. Stacks

Foreign

Carlton G. Agle, Germany; Prija Chongvatana, Thailand; William Elrick, Singapore; Madhav Narayan Kango, India; Jan Kraay, Belgian Congo; Edmundo B. Lucius, Argentina; Hans Mersheimer, Germany; T. Sornam, India; R. Venkatasubramanian; India; K. Viswanathan, India



New on the 60's

TUNG-SOL
CARTRIDGE LAMPS

These new miniature automotive lamps are already seeing service in leading 1960 trucks and passenger vehicles. And judging from their versatility in application, they are expected shortly to become an important staple in almost all modern car and truck design.

Of European origin, the cartridge lamps are being domestically manufactured solely by Tung-Sol. And it takes Tung-Sol, the foremost automotive lamp manufacturer with its consistently high production standards, to make these economical miniature lamps and meet the high-efficiency lighting demands of today's vehicles. For more information write to Tung-Sol Electric Inc., Newark 4, N. J. TWX: NK193

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SALES OFFICES: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Montreal, P.Q.

EVANS HEATERS ARE RIGHT FOR TRUCKS BECAUSE THEY'RE BUILT FOR TRUCKS!

There's as big a difference between truck and car heaters as there is between truck and car tires. The rugged construction of Evans truck-built heaters . . . the combination of the right BTU rating and *proper heat distribution* . . . just can't be matched by heaters built for cars. Whatever your truck heating requirements, our engineers are ready to work with yours to design an Evans heater to do the job. Write Evans Products Company, Dept. Z11, Plymouth, Mich.

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EVANS

TRUCK AND BUS HEATERS AND VENTILATING SYSTEMS

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EVANS PRODUCTS COMPANY

Plymouth, Michigan

The Finest Products
Made with Aluminum

How Aluminum Bumpers can save $4.00 per car

Aluminum Bumpers give you production savings, design versatility, weight reduction and lasting beauty

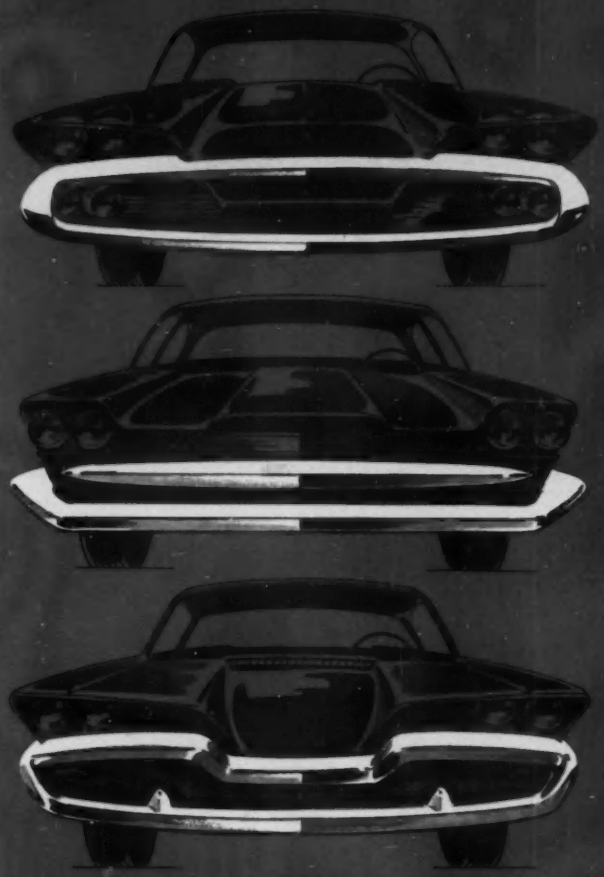
Formed Extrusions Recent Reynolds developments in manufacturing and metallurgical practices with formed aluminum extrusions, point out both the practicality and economy of aluminum for bumper application. Reynolds work with forming techniques has demonstrated that complex shapes can be formed without sacrifice of mechanical properties and without impairing brightness of the anodized surface.

Fabricating Savings Depending on size and design, formed extruded aluminum bumpers can be fabricated with a per bumper saving of $1.25 to $3.00. An average saving of $2.00 per bumper or $4.00 per car is very realistic.

Styling and Design Versatility Deep recesses or grooves can be easily designed into aluminum bumper extrusions to achieve styling effects that cannot be accomplished with other metals. Also, aluminum extrusions can be anodized to full thickness even though grooves and recesses are specified. This cannot be done with plating processes on other metals. For this reason, it is safer to design with aluminum from a warranty cost standpoint than to take a chance with other metals. Contrasting colors can also be added through the use of organic finishes—paint films adhere to anodized aluminum remarkably better than to other bright trim materials.

Strength Average material in the conventional bumper has a yield strength of somewhere between 25,000 and 30,000 pounds per square inch. Aluminum alloys used by Reynolds in sample bumper fabrication have a yield strength of 31,000 pounds per square inch. Reinforcing members integral with the extrusion can be easily designed into the bumper for even greater strength.

Lighter Weight Current bumpers average out at 36 to 40 pounds. Comparable designs in aluminum weigh 15 to 22 pounds. Average weight savings per car with aluminum bumpers are estimated at around 40 pounds. Aluminum bumpers can cut "overhang" weight, give brakes less load to stop—aid in the overall automobile design programs to reduce deadweight and improve car performance.



On bumper applications and on countless others, Reynolds Aluminum Specialists will be glad to work with you to help you get the very most from the aluminum you use. For details on this service and on aluminum mill products or fabricated aluminum parts and trim, *contact Reynolds Metals Company new sales office at Northland Drive and Northwestern Highway, P.O. Box 5050, Seven Oaks Station, Detroit 35—phone KEnwood 7-5000. Or contact your nearest Reynolds Office or write P.O. Box 2346-MZ, Richmond 18, Virginia.*

Watch Reynolds TV shows—"ALL-STAR GOLF" and "ADVENTURES IN PARADISE"—ABC-TV

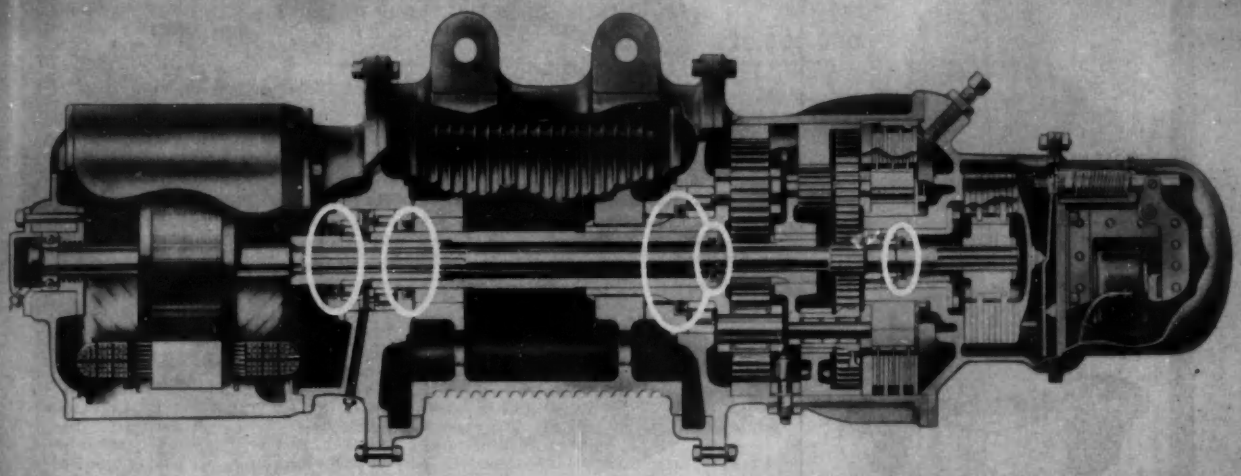
NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower final cost.

Reynolds Aluminum

the metal for *automation*

TRADE MARK

MORE ABOUT THE GARLOCK **2,000**



General-purpose KLOZURE Oil Seals (Model 63 cutaway right) afford complete protection at important bearing locations (circled above) on the Shepard-Niles "Liftabout" Hoist.

Garlock Klozure* Oil Seals

assure durable, dependable performance on tough sealing jobs

Friction and bearing wear, hazardous to any industry, are especially harmful in materials handling. That's why Shepard-Niles and other leading crane and hoist manufacturers specify Garlock KLOZURE Oil Seals for complete bearing protection. Shepard-Niles "Liftabout" is typical of how Garlock KLOZURES not only exclude dust and foreign matter from bearings but also retain the important lubrication—both of which add to greater dependability during rugged hoist operation.

Designing Garlock KLOZURES into your equipment protects bearings with oil seals that are durable, economical, and easy to replace. Garlock KLOZURES can be applied on low, medium, or high speed service. Whether your application is general-purpose in nature, or there's a specific job to be done, Garlock has a KLOZURE design for you.

KLOZURES are another of the Garlock 2,000 . . . two thousand types of packings, gaskets, and seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative.

Call him or write for KLOZURE Catalog 20.

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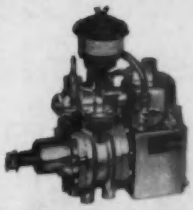
THE GARLOCK PACKING COMPANY, Palmyra, N. Y.
For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

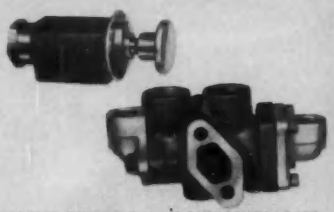
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products.

Use Wagner Air Brake Components to Increase Safety . . . Reduce Maintenance!



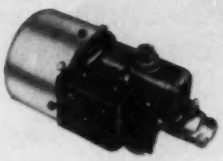
ROTARY AIR COMPRESSORS have a low temperature air delivery. This prevents carbon formation—reduces fire hazard—lets you use flexible connection in discharge line. Rotary operation provides thousands of overlapping air compression impulses per minute for smoother, quieter operation—increased belt and coupler life.

BRAKE CHAMBERS have fully oil-resistant diaphragms of nylon and neoprene to provide much better wear characteristics—less deterioration. All metal parts are of corrosion-resistant material, or are plated to prevent corrosion. Diaphragms are interchangeable—will fit in other makes of brake chambers.



TRACTOR PROTECTION and EMERGENCY BRAKE VALVES for combination vehicles—provide manual and fully automatic protection. In emergency they can be triggered by pulling the valve knob—however, the fully automatic units will activate without driver attention in any emergency due to trailer break-away or air loss failure.

BRAKE APPLICATION VALVES. Hand valve is designed with extra long handle for convenient operation. Gives driver independent control of trailer brakes for smooth stops through entire range of deceleration. Foot application valve meters air smoothly through the range from slow to emergency deceleration—has extra high flow capacity—is light in weight and simple to service.



POWER CLUSTER converts 100 p.s.i. of air pressure into approximately 1500 p.s.i. of unvarying hydraulic pressure. Gives much more uniform metering control than "booster" type hydraulic units. Provides power actuation through the entire range of braking and, in connection with our application valve, gives "low pedal" hydraulic brake operation.

RELAY QUICK-RELEASE VALVE controls the brakes on specific axles, acting in unison with the driver-controlled application valves. Automatically meters pressure directly from a reservoir tank, speeding normal braking and release. Low differential between input and output pressures provides better balanced braking actuation.

LOW PRESSURE INDICATOR—buzzer or lamp—warns the driver if air pressure falls below the safe driving range. Warning circuit is controlled by a pneumatic switch which is connected to the pressure side of the air brake system. Unit automatically closes the circuit if pressure drops below a predetermined value.

MOISTURE EJECTION VALVE prevents moisture accumulation in the air tank. It is fully automatic, operating in the 15-25 p.s.i. pressure range. Normal brake applications operate the valve, keeping reservoir clean and moisture-free. Expulsions occur without a notable drop in gauge pressure.

ALCOHOL INJECTOR keeps air lines and air reservoir free of ice. Connects to the discharge side of the compressor—does not contaminate the oil. Is of all-metal construction—no glass to break. Has extra large capacity—requires less frequent refilling.

WK59-7

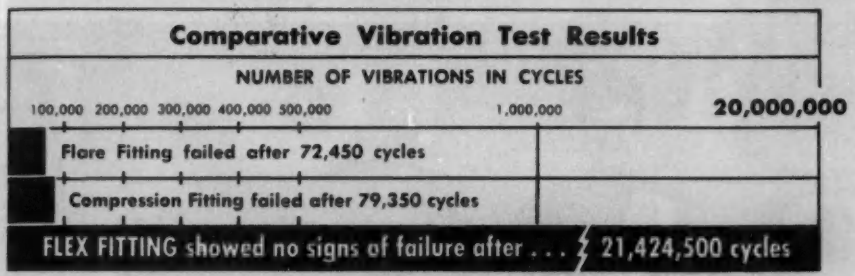
Wagner Electric Corporation
6378 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U. S. A.

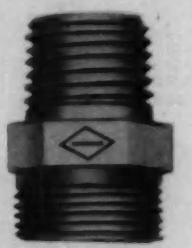
Use Wagner Air Brake Components for complete air brake systems—fully described in Catalog KU-201. Write for your copy today.

LOCKHEED BRAKE PARTS, FLUID, LINING and LINED SHOES • AIR HORNS • AIR BRAKES • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS


Comparative Vibration Test Results
NUMBER OF VIBRATIONS IN CYCLES
100,000 200,000 300,000 400,000 500,000
1,000,000
20,000,000
Flare Fitting failed after 72,450 cycles
Compression Fitting failed after 79,350 cycles
FLEX FITTING showed no signs of failure after . . . 21,424,500 cycles



Flex tube fittings withstand over 20-million cycles of vibration without failure

To cope with major vibration in fuel, oil, and vacuum lines serving cars, buses, tractors, trucks, and power units — nonrigid tube connections are preferred. Imperial Flex tube fittings have been proven to withstand over 20-million cycles of vibration without failure! (See bar graph above.)

Such top operating dependability is but one of the money-saving advantages of Imperial Flex fittings. These fittings also eliminate costly flexible hose lines except where there is extensive tube movement.

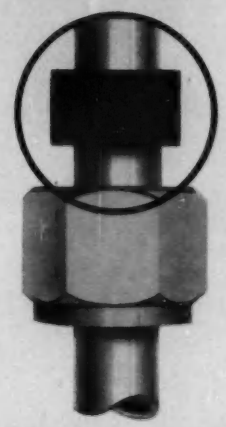
Design engineers point out that tube failure is caused by fracture due to metal fatigue and crystallization — a result of constant shock and vibration. Another cause for failure is tube distortion in making the connection.

ELASTIC SLEEVE — To overcome these and other rigid fitting joint handicaps, Imperial designed an elastic sleeve to cushion and absorb vibration. This special synthetic sleeve permits the tube to flex back and forth while continuing to maintain a positive, pressure-tight seal.

These reliable Flex fittings can be used for connecting all types of seamed and seamless metal tubing: copper, aluminum, thin-wall steel (such as Bundy or GM), Monel, stainless steel, Everdur and many others.

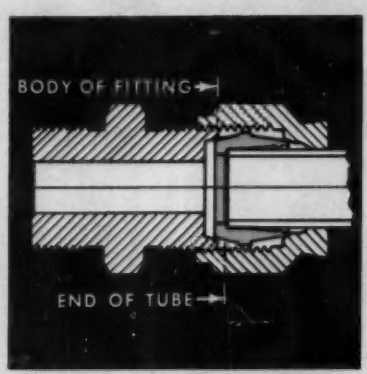
EASY INSTALLATION — To install Imperial Flex fittings for tubing ½" O.D. or smaller, just slip nut and flex sleeve over tubing. Insert tubing in fitting body as far as it will go and assemble. Positive stop nut prevents over-tightening.

Write for Catalog No. 344



No metal-to-metal contact with Imperial Flex fittings! Husky, resilient sleeve (encircled) withstands gas and oil . . . flexes perfectly in sub-zero to 250° F. temperatures. For ⅛" to ⅜" O.D. tubing.

Imperial Hi-Seal tube fitting design offers greater reliability, simplifies installation of hydraulic systems



Butt-joint simplifies installation. Tube doesn't enter body of fitting. It bottoms on shoulder of sleeve. No tube torqueing when making joint.

The superior design of Imperial Hi-Seal tube fittings pays off in reliability, simplified tube connections and reduced assembly time.

With Hi-Seal, the tube *does not* enter body of the fitting — it bottoms on shoulder of the sleeve. No need to spring tubing. Closer tube bends are possible — no flaring or threading is necessary. Joints stay pressure-tight beyond the burst strength of the tubing itself!

Hi-Seal tube fittings are available in brass, steel and stainless steel, for ⅛" to 1½" O.D. tubing. Long dryseal pipe threads are provided on all pipe ends.

Write for Bulletin No. 3061

Hi-Seal conforms to J.I.C., A.S.M.E. and A.S.A. standards.

CONTACT YOUR IMPERIAL REPRESENTATIVE OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. SAE-119, 6300 W. Howard St.
Chicago 48, Ill.
Please rush me:
Bulletins ☐ No. 344 ☐ No. 3061

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THE IMPERIAL BRASS MFG. CO.
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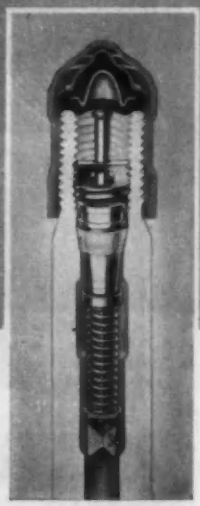
The American Automotive Industry – the world's

Complete tire-air

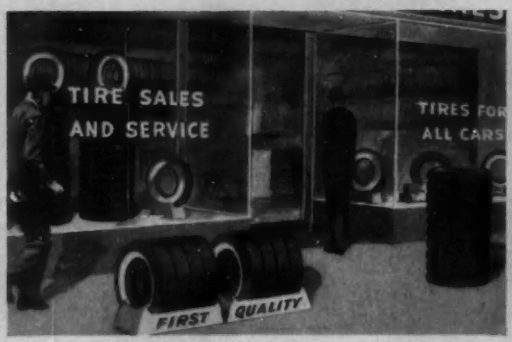


AIR CONTROL Since 1844

Schrader's famous tire valve operating principle is the Ace of Standardization for the vast numbers of tires now in use in countries around the globe.

greatest enterprise—depends on tire accomplishments

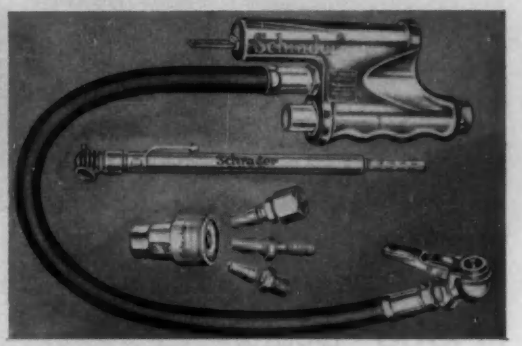
service everywhere keeps vehicles rolling



TIRE OUTLETS make tires available in quantity to all users. The right tire for the right vehicle is always available from their stocks.

TIRE REPAIR DEPOTS specialize in getting all the mileage from tires by providing vital air pressure facilities, recapping, fixing flats, replacing valves, etc.

DEALERS make tire-air service as readily available as newspapers to the millions of cars now rolling throughout the world . . . a prime automotive service.



SCHRADER SERVICE TOOLS and standard valve replacement parts are as available as tires. Tires also must be air serviced anywhere a vehicle rolls.

World-wide transportation would collapse without good tire service. Weather, rocks, and rough terrain slash at tires day-in and day-out. Only through the effective cooperation of many companies in the Automotive, Tire, and Tire Valve industries has good service been made available everywhere. For example, Schrader's job for over sixty years has been to seal air in tires with the safest, most practical valves possible to provide . . . interchangeable, low cost Caps and Cores of high quality for any tire . . . simple, time saving tools for gauging, inflating and sealing . . . up-to-date information. Depend on Schrader valve and equipment design, production and distribution to match the built-in performance of your vehicles and tires wherever they roll.

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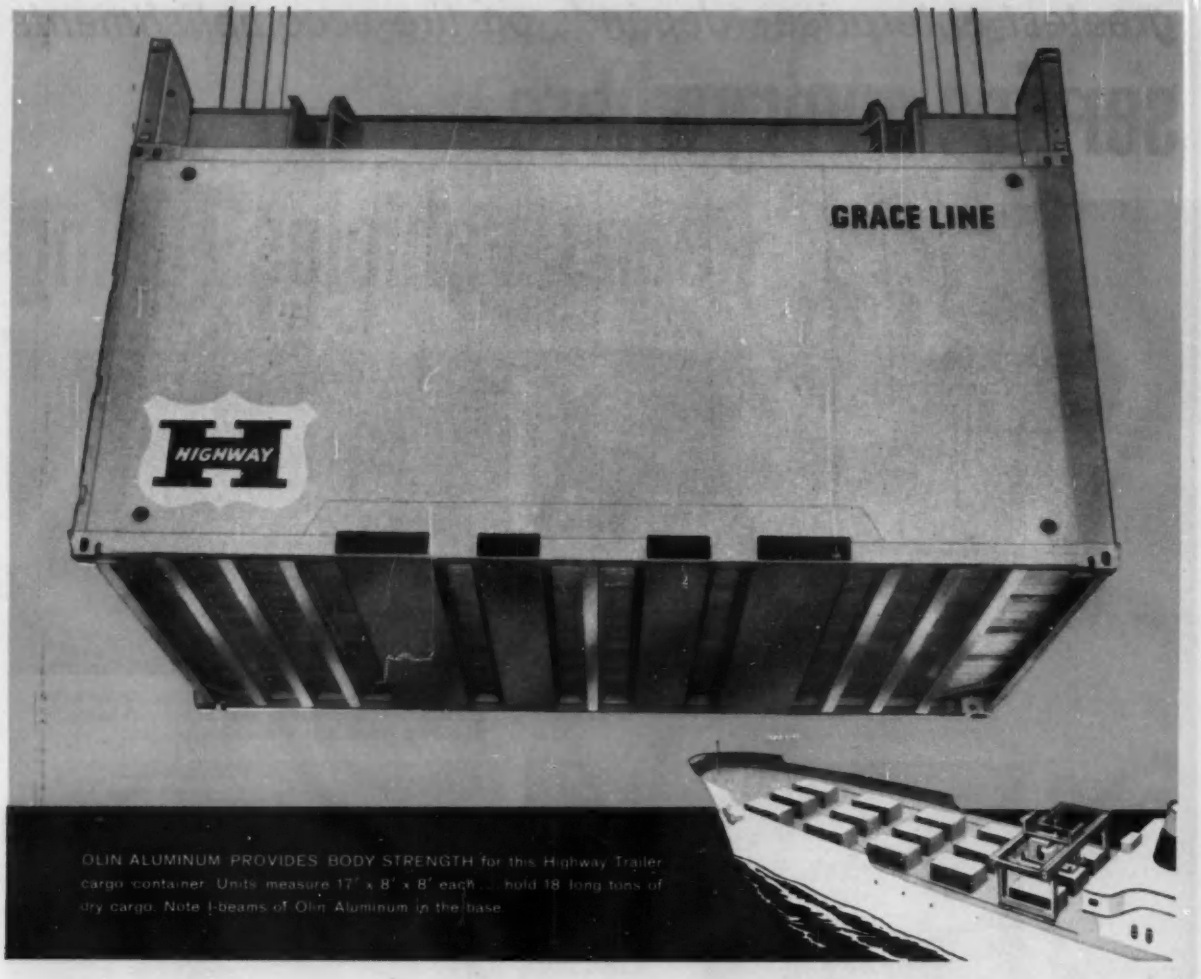
FIRST NAME IN TIRE VALVES

FOR ORIGINAL EQUIPMENT AND REPLACEMENT



OLIN ALUMINUM PROVIDES BODY STRENGTH for this Highway Trailer cargo container. Units measure 17' x 8' x 8' each ... hold 18 long tons of dry cargo. Note I-beams of Olin Aluminum in the base.

Olin Aluminum adds strength, cuts weight in 1500 "Seatainers"

Grace Line is now accepting what is reported to be the largest single order to date of seagoing cargo containers — 1500 "Seatainers" manufactured by Highway Trailer Company of Wisconsin.

These containers can be carried by truck or train ... before and after travelling aboard the Grace Line's specially converted cargo ships. Purpose of the units is to avoid rehandling of cargo as it's transferred from one mode of transportation to another.

For strength and lightness, the floor stringers and top stringers in the containers are extruded I-beams of Olin Aluminum. For resistance to corrosion by wind, water and salt spray ... Olin Aluminum extrusions form the weather-stripping and door-stop moulding.

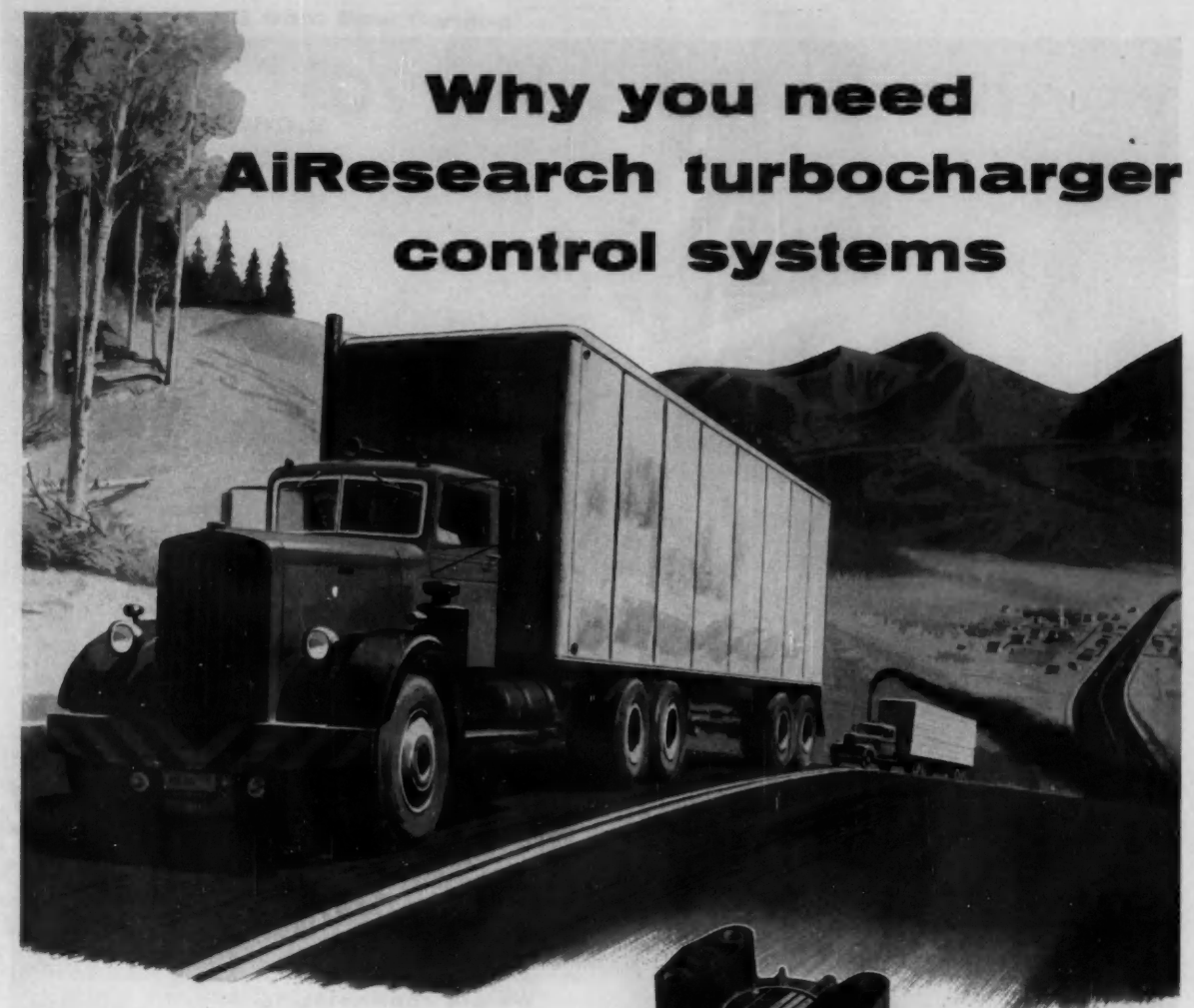
Alert manufacturers in the transport industries are depending on Olin Aluminum ... today's fast-moving metal for high-stepping transportation.

SEE EDWARD R. MURROW ON "SMALL WORLD"—EVERY SUNDAY EVENING, CBS-TV

OLIN ALUMINUM®

OLIN MATHIESON • METALS DIVISION • 400 PARK AVENUE • NEW YORK 22, N. Y.

Why you need AiResearch turbocharger control systems



The two components of the AiResearch turbocharger control system are a speed sensor and an exhaust by-pass valve. They control the speed of exhaust-driven turbochargers by modulating the amount of engine exhaust used.

The AiResearch turbocharger control system delivers more air to the turbocharged engine automatically when needed. This more than doubles the torque rise and gives the engine much greater lugging ability under heavy loads.

AiResearch is the leader in the development and production of turbocharger controls for all major diesel engine applications as well as air-cooled turbochargers for diesel engines from 50 to 700 H.P. Your inquiries are invited.

Reduced fuel consumption

•

Smoking eliminated

•

Longer engine life

•

Lower maintenance costs

•

Shorter running time

•

Better engine lugging

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

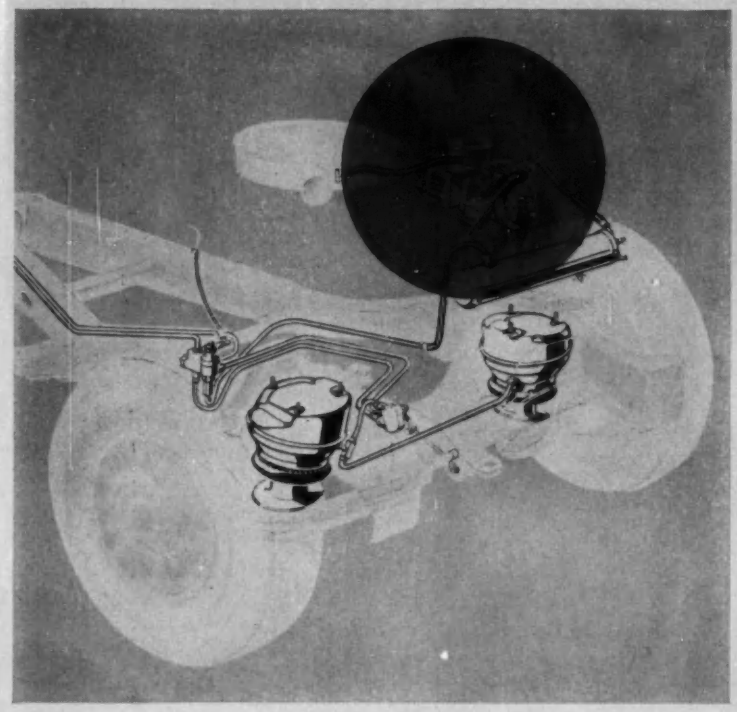
McLOUTH STEEL CORPORATION

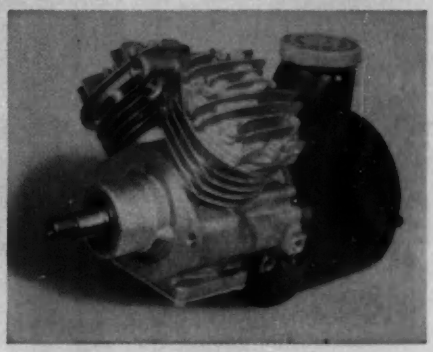
HOT AND COLD ROLLED SHEET AND STRIP STEELS

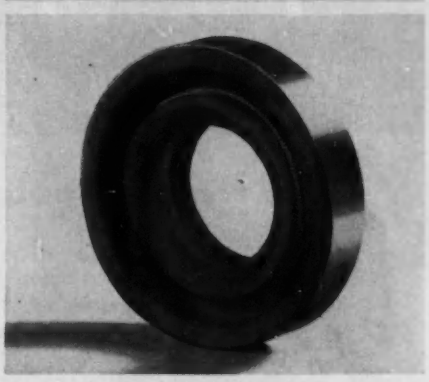
Detroit 17, Michigan

SILICONE NEWS from Dow Corning

Seals Hot Oil, Stays Springy







SILASTIC Keeps Fluid in Place at −30 and 350 F

Here is a rubbery material that resists automotive hydraulic fluid and stays springy over a wide temperature range. It's Silastic, the Dow Corning silicone rubber, and it's doing rugged duty in some new cars.

Automotive engineers designed the dual device shown above. It consists of an air compressor and a pump assembly, operating in tandem off the same drive shaft . . . one pumping a synthetic hydraulic fluid to the power steering system, the other compressing air for pneumatic suspension. Obviously, some sort of seal was necessary to prevent fluid from leaking along the shaft from the pump into the air compressor. Because of possible shaft wobble or misalignment, the seal had to be flexible.

To solve the problem, they engineered a floating oil seal of Silastic. Thanks to the properties of Silastic, this seal works beautifully despite rpm's up to 6,000 and operating temperatures up to 350 F. The Silastic is also completely flexible at —30 F and is actually suitable for use from —130 to 500 F. The engineers are so pleased with the field performance of Silastic that they're now considering extending its use to many other new product design areas.

If you have need of such a flexible, durable material, investigate Silastic. Your rubber fabricator can engineer a part to your specifications. Or, for data, write Dow Corning, Dept. 9123a.

Typical Properties of Silastic for Seals

Temperature range, F	—130 to 500
Tensile Strength, psi	600 to 1400
Elongation, %	150 to 300
Tear Strength, lb/in	40 to 180
Compression set, % @ 300 F	5 to 50
@ 450 F	60
Hardness Range, durometer	20 to 80

If you consider *all* the properties of a silicone rubber, you'll *specify Silastic.*

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

IT'S ICE-SLICK

Won't Stick at 30° Below

Try C/R K-400 Cups for Smoother Power Cycles

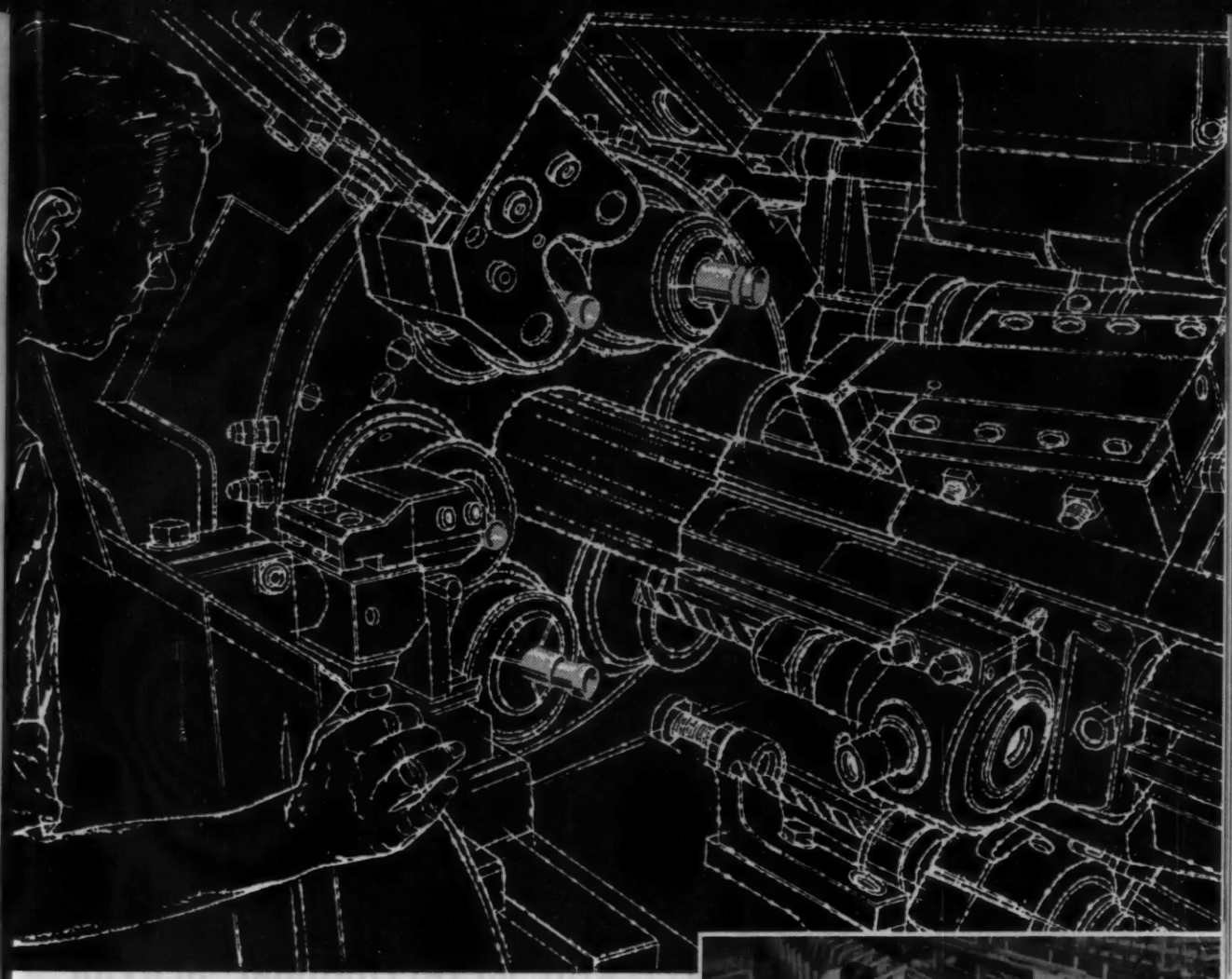
Any time you face the problem of reducing cylinder cup breakaway or sliding friction, chattering or freezing, come see us. We're reasonably certain that Chicago Rawhide's Sirvis Leather K-400 cups can help you. Their specialty is easy sliding — particularly in vacuum cylinders at sub-zero temperatures and in pneumatic cylinders at ambient temperatures and low pressures. Tests show a 50% reduction in breakaway and sliding friction over standard leather cups at ambient temperatures . . . and these K-400 cups are functioning beautifully in applications at -30° F. In another test, C/R Sirvis K-400 cups were run well over one million cycles at 20" of vacuum with negligible leakage and wear.

So if you are trying to design a new, smooth-working, low-friction pneumatic cylinder — or take the bugs out of an old one — jot down C/R K-400 cups and call us.

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVIS DIVISION, 1243 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic gears

C/R



The Ultimate Test

The ultimate test of quality in stainless steel bars takes place in screw machine production, where every bar is literally cut to pieces.

The Perry-Fay Company, Elyria, Ohio, a leader in screw machine production, has been subjecting J&L bars to this demanding production-line test for more than a year, **without a single failure, without a single reject.** Perry-Fay reports: "We consistently get superior surface finish, closer tolerances, fully formed rolled threads with J&L stainless bars."

Whether you need stainless steel bar stock for high-speed, high-production operations, or a single bar for extraordinary requirements, turn to J&L. J&L leads the industry in melt shop standards for stainless steel, the point where quality starts—and new production profits begin.

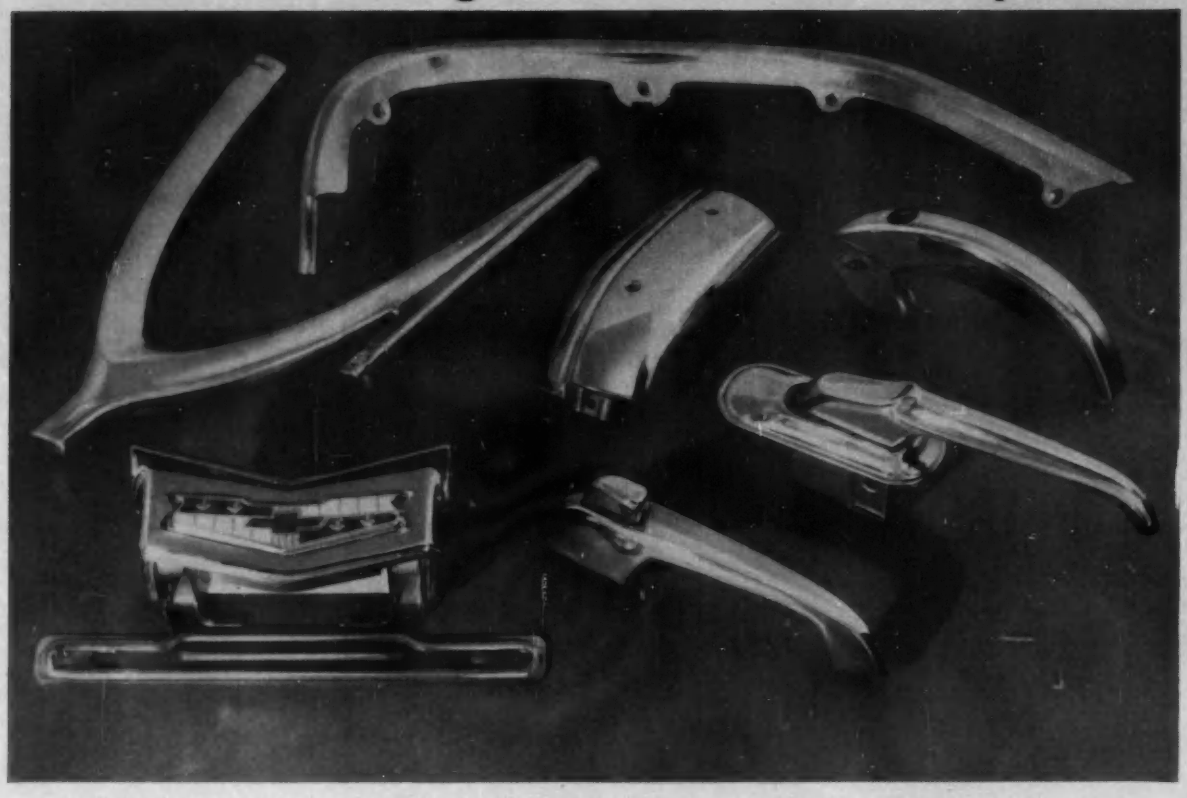
Careful attention to every production detail is the key to J&L quality.

J&L STAINLESS
SHEET • STRIP • BAR • WIRE

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

Problem-Solving Products from Republic:



Illustrated are parts and molding fabricated from Republic ENDURO Stainless Steel by Keeler Brass Company, Grand Rapids, Michigan.

STAINLESS STEEL QUALITY AND METALLURGICAL SERVICE HELP FABRICATOR STAY COMPETITIVE...AT A PROFIT

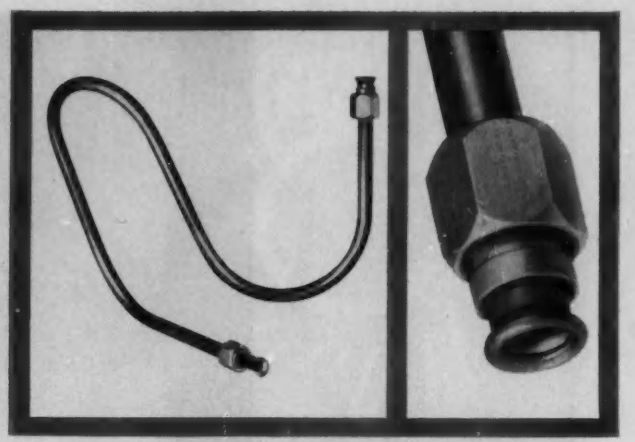
"Republic Steel Corporation's consistently high quality stainless steel, backed by excellent metallurgical service, enables us to maintain a profitable position in the highly competitive automotive part and trim business", says Mr. Julian Kempski, Purchasing Agent, Keeler Brass Company, Grand Rapids, Michigan. The company fabricates a wide variety of parts and trim from Republic ENDURO® Stainless Steel.

Republic Stainless Steel quality has to be good to meet Keeler's strict requirements. Some of the parts are subjected to the most severe forming operations possible. Physicals must be exact to meet forming, bending, and drawing requirements . . . and to eliminate scrap loss. The chemistry has to be just right for maximum corrosion-resistance in the end product.

Controlled rolling and annealing operations performed by Republic result in quality stainless steel with uniform flatness, fine surface, and desirable physical properties for fabricating. These features, combined with Republic metallurgical service, enable Keeler to maintain profitable production in a highly competitive market.

Republic's famed 3-Dimension Metallurgical Service is available to all stainless steel users. Field, mill, and laboratory metallurgists, working as a team, will assist you in selection, application, and processing of the right stainless steel for your requirement. There is no obligation. Mail coupon for more information.

REPUBLIC NYLOK® STUDS SOLVE FASTENING PROBLEM for Gravely Tractors, Inc., Dunbar, West Virginia. Problem: Find a dependable fastening method for tractor-attached rotary cultivators. Fastener must withstand constant shocks and pounding of rotary cultivating. Solution: Use Republic Nylok Studs. A special nylon insert assures positive locking at any position, even under severe shock, vibration, tension. Prevents all play. Utilizes metal-to-metal contact of opposing threads for locking. Republic Nylok Fasteners—studs, nuts, cap screws—resist heat, cold, moisture. Can be re-used. Mail coupon for full facts.



REPUBLIC ELECTRUNITE® HYDRAULIC FLUID LINE TUBING SOLVES FAILURE PROBLEM resulting from longitudinal or transverse cracks. No failure from these causes has been reported in the history of the product. ELECTRUNITE Fluid Line Tubing gives you more tube per dollar. It provides utmost uniformity, assures better bending and flaring characteristics, offers appreciable savings in downtime. Available in all sizes shown in JIC Standards Book, and meets the requirements of SAE Standard. Available in an even wider range of sizes produced to our specification HL-1 (which meets all test requirements of JIC Standards). Mail the coupon for complete facts.

REPUBLIC COLD DRAWN ALLOY BARS SOLVE KINGPIN PROBLEM in White Motor Trucks. In maintaining the safety of these trucks, their drivers, and the millions of dollars worth of merchandise they carry each year, White produces critical kingpins of 1⅞" round Republic 8620 Alloy Cold Drawn Bars. Republic Cold Finished Alloy Steels are available in every standard analysis, plus many specials. For further information, mail coupon.

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World's Widest Range of Standard Steels and Steel Products

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☐ Stainless Steel
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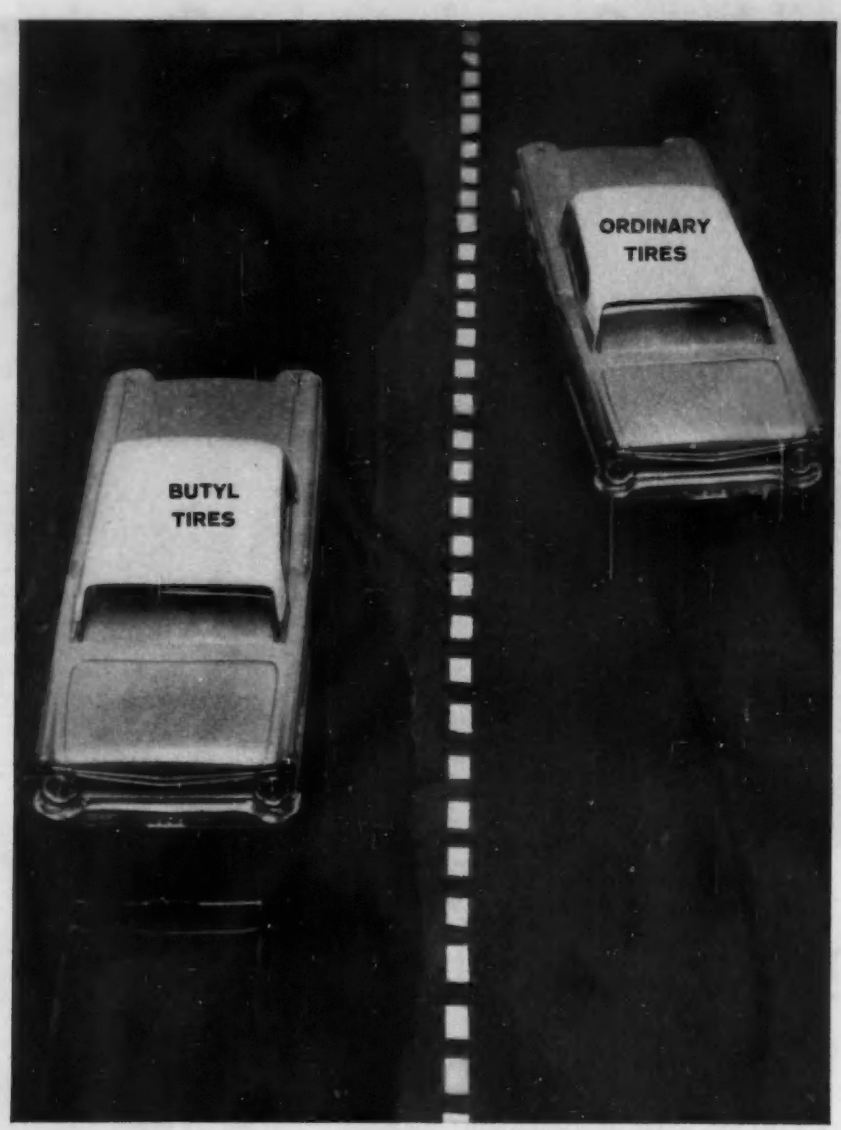


Enjay Butyl does amazing things for tires. This picture demonstrates how tires of Enjay Butyl stop faster on wet road than ordinary tires do on dry road.

ENJAY BUTYL RUBBER MAKES TIRES PERFORM BETTER

A revolutionary new tire is being made today. It's made of Enjay Butyl rubber to bring new highs in traction and shock absorption while allowing designers greater freedom in tread and cord design Butyl thus enables tire manufacturers to produce tires with unique silence, safety, appearance and comfort.

SAFETY AND SILENCE — So effective is the traction of Enjay Butyl tires, that they stop up to 30% faster than ordinary tires! Stop faster on wet roads than other tires do on dry! And Butyl tires will not screech on any corner at any speed!

RIDING COMFORT — Because Butyl absorbs shock energy more completely, Butyl tires literally upgrade riding comfort in any car. Detroit engineers report tires of Butyl will help minimize the need for major engineering changes to overcome vibration and noise in tomorrow's new cars.

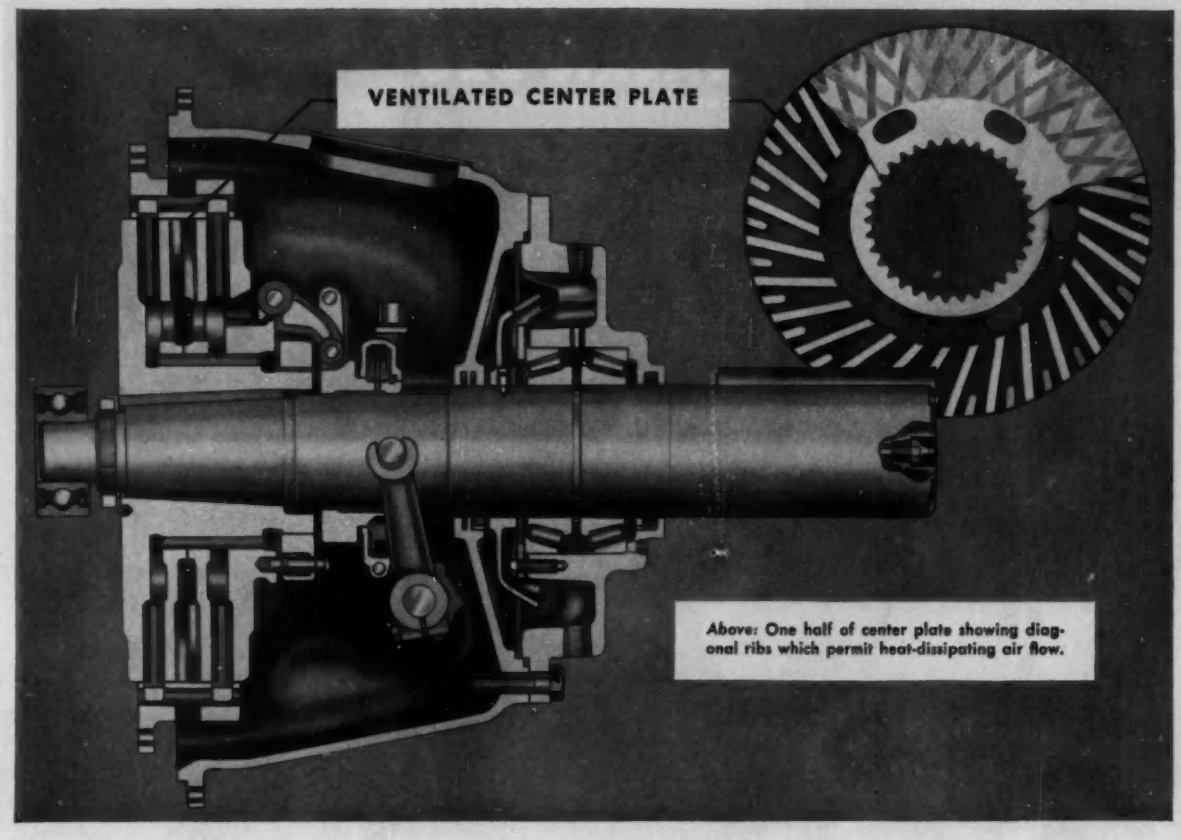
UPGRADES OTHER PARTS, TOO — Enjay Butyl is already used in more than 100 places in today's cars — parts such as inner tubes, weatherstrips, shock absorbers, motor mounts. Let us show you how Butyl can help make better rubber products. Call or write your nearest Enjay office.

ENJAY® BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa



High-energy, high-speed power take-off

features ventilated center plate and oil-lubricated tapered roller bearing

Here is a new PTO—Twin Disc Model IBF-214P—designed for high-speed engines not yet off the drawing board . . . *engines developing 300 to 500 hp at speeds up to 3380 rpm!*

These high speeds are possible because of improved design including the elimination of heavy counterweights, thereby improving overall balance and reducing link and pin stresses.

In addition to its high speed rating, this new unit offers two other important advantages over standard PTO's:

1) The ability to withstand high-energy loads through use of a unique center plate design.

High-energy heat loads create uneven thermal stresses which in turn cause clutch failure by starting cracks in the center plate. This problem is usually traceable to heavy starting loads such as occur in rock crushers, heavily-loaded conveyors and similar equipment.

The center plate on the Model IBF-214P Power Take-Off is ventilated by means of a two-piece design with diagonal ribs cast into each plate. Placed back to back, the ribs cross each other to form only small diamond-shaped contact areas, thus allowing air flow to dissipate excess heat.

2) The ability to operate for six months between lubrication periods thanks to improved throw-out collar design and oil lubrication of the tapered roller bearing.

Oil rather than grease is used for bearing lubrication so as to assure safe operating temperatures at the high speeds for which this unit is designed. The top of the bearing carrier has a small cast cavity which is kept full of oil by a slinger dipping into the sump. A drilled hole from this cavity feeds the bearing to assure constant oil circulation.

A special clutch engagement mechanism cuts throw-out collar wear. Lubrication is needed only twice a year in normal service.

Complete details and specifications on Model IBF-214P are available from our Racine office. Request Bulletin No. 308-B, Supplement A.

TWIN DISC

TWIN DISC

Friction Clutches and

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois

NAUGATUCK PARACRIL OZO

THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER

Now—the finest weather-resistant wire jackets can be Colored!

FOR SALES APPEAL • FOR SERVICE EASE

New Paracril OZO—a superior rubber compound developed by Naugatuck—makes possible *new eye appeal, new ease of identification*. And it outperforms standard wire jacket compounds many other ways, too!

Compare new PARACRIL OZO with other wire jacket rubbers. Prove for yourself, new PARACRIL OZO gives:

- significantly superior ozone resistance
- greater fuel and oil resistance
- much greater abrasion resistance than standard jacket compounds
- excellent processability, with particularly fast extrusion
- *permanent retention of bright colors!*

If you are not already using PARACRIL® for your wire jacket compounds or similar products requiring such properties, chances are 1000 to 1 it's because you haven't yet *tried* PARACRIL OZO.

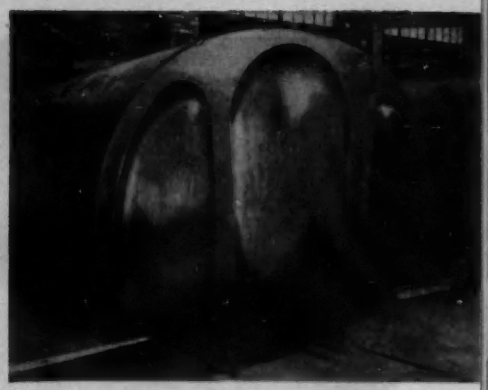
Why *not* try it—soon. Contact your nearest Naugatuck representative at the address below.

Naugatuck Chemical

Division of United States Rubber Company 1128 F Elm Street Naugatuck, Connecticut

US RUBBER

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Uniroyport, N.Y.



Brownie Stress Distributing Head *fabricated from Youngstown Yoloy "E" High-Strength Steel distributes liquid surge shocks and vertical load within trailer tanks.*

Accent on Excellence

Youngstown Yoloy "E" high-strength steel

This new, rugged Brownie trailer tank train can haul 11,500 gallons of petroleum products in a single trip! Its tank shells and internal stress distributing heads are fabricated exclusively from Youngstown Yoloy "E" Steel. This high-strength, low-alloy steel provides a stronger, lighter rig that carries larger payloads, requires little maintenance.

Brown Steel Tank Company of Minneapolis reports that Yoloy "E" withstands corrosion, resists shock and fatigue, and offers excellent weldability and formability . . . "naturals" for tank builder and user alike.

Wherever high-strength steel becomes a part of things *you* make, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create products with an "accent on excellence". The Youngstown Sheet and Tube Company, Youngstown, Ohio. Carbon, Alloy and Yoloy Steel.

Youngstown

Send for free technical bulletin on Youngstown Yoloy "E" Steel.

No formality!

A simple phone call . . . brings a Resident Doehler-Jarvis Sales Engineer.

and/or sub-assembling the finished parts . . .

How to contact your Doehler-Jarvis Resident Engineer

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Doehler-Jarvis

Division of
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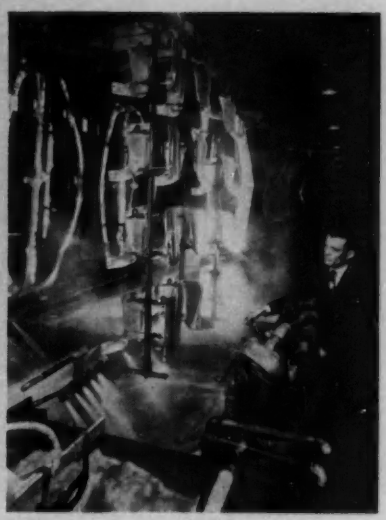
★Barber Die Casting Co. Limited
Hamilton, Ontario

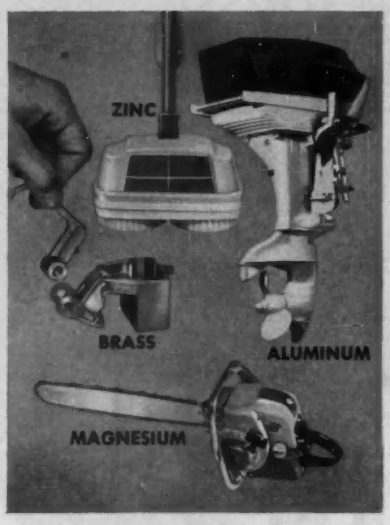
Never has as satisfactory

As the pictures above imply . . . Doehler-Jarvis makes the buying of die castings a simple matter today.

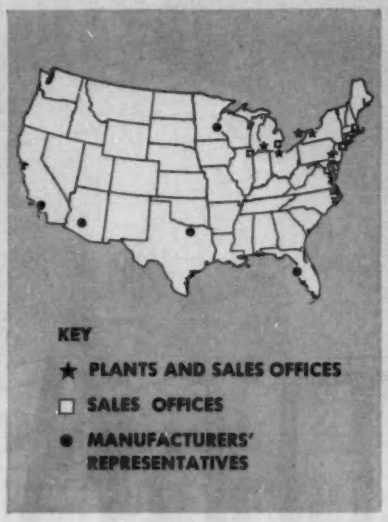
First, you deal with a Doehler-Jarvis Resident Engineer. Through him you can tap the full production and engineering talent of the most experienced company in die casting . . . no matter how large or small your requirements. Through him you obtain personal day to day liaison that insures maximum production economy through personal attention to your needs and problems.



You get immediate help in engineering the design . . . and evaluating the economics of die casting . . . plating or otherwise finishing . . .



using the most appropriate die casting alloys.



Large, fully-equipped Doehler-Jarvis plants . . .

assure economical production, reliable delivery.

the buying of die castings been as simple or as Doehler-Jarvis makes it today!

Second, in addition to the castings themselves, Doehler-Jarvis provides added resources you may need: ample alloy stocks; fully equipped die making shops; complete facilities for light metal working, including machining, finishing and sub-assembly lines; spacious die and parts storage; a huge tractor-trailer fleet to *assure* delivery.

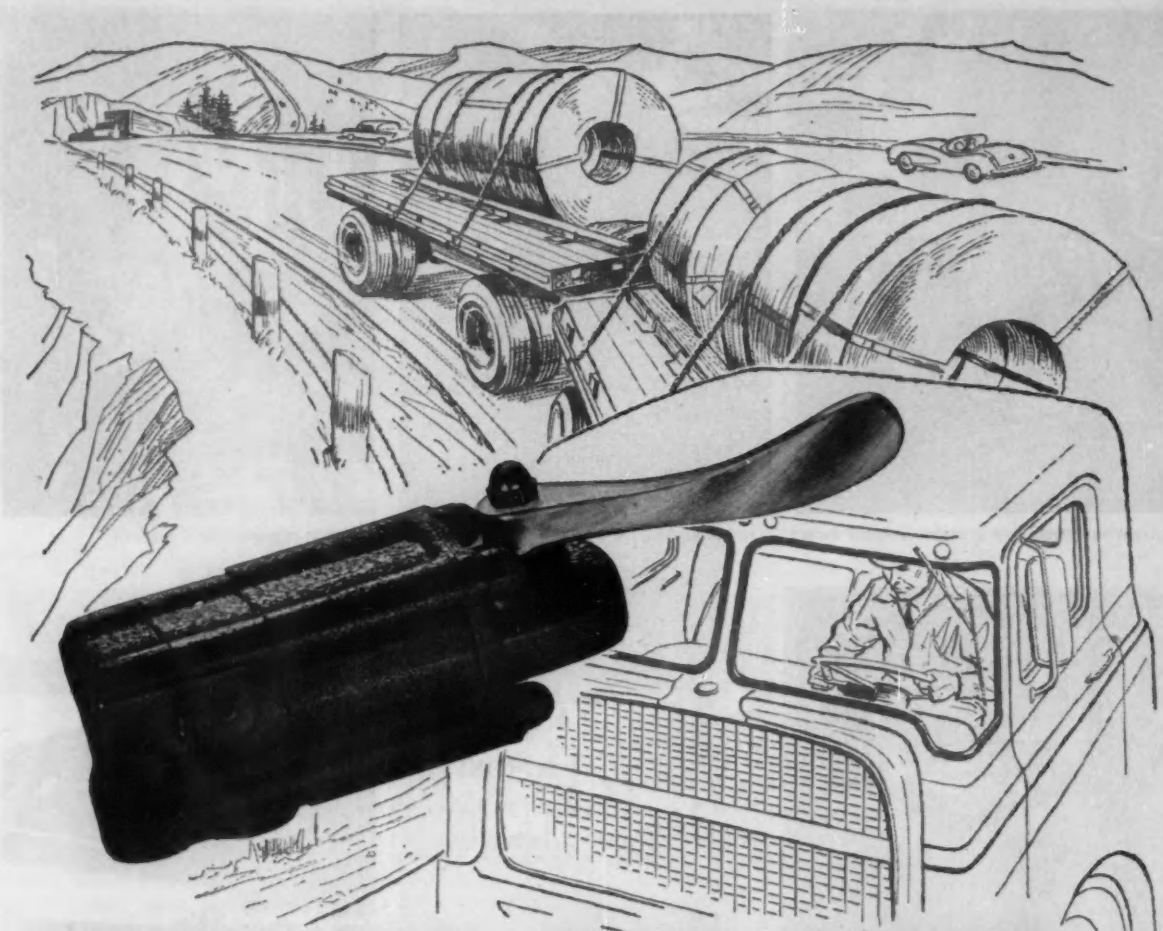
Thirdly, you can be sure that Doehler-Jarvis has in its eight plants, the productive capacity to meet your schedules no matter how large . . . and a flexible organization to give them proper attention no matter how small.

Small wonder that many companies, large and small, look upon Doehler-Jarvis almost as a department of their own plant. That's true of makers of hand power tools, of floor waxers, of sprinklers and garden hose fittings, of chain saws, of typewriters, of kitchen and other appliances, of hundreds of other products.

Doehler-Jarvis has served many companies for more than a quarter century, some for better than 50 years. Proof enough that no other die caster provides more quality, more service and more overall economy to the customer. Ask your Doehler-Jarvis Resident Engineer to tell you how much we are prepared to do to establish equally satisfactory supplier-purchaser relations with you.

Doehler-Jarvis

Division of
NATIONAL LEAD COMPANY



MIDLAND

HAND CONTROL VALVES

NEW DESIGN ADAPTS VALVE TO THREE TYPES OF MOUNTINGS

Mount Midland's new Air Hand Control Valve on the steering column, on the dash board, or as a remote control unit. It's versatile!

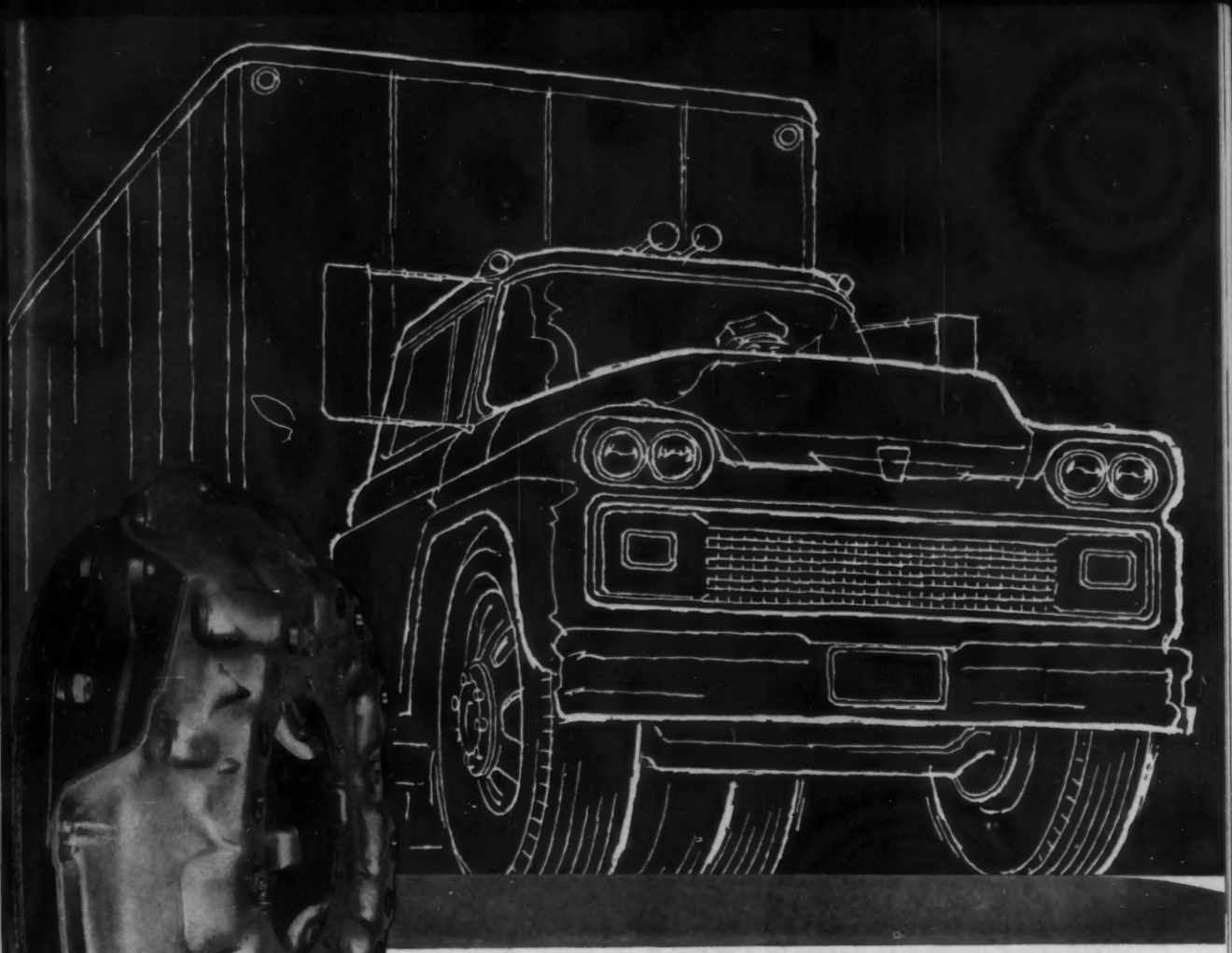
Made of light weight aluminum, the new valve weighs only 1½ lbs. And Midland engineers have accelerated the application and release time . . . longer brake and tire life! Drivers have a greater safety margin . . . through more braking control.

Write today. Ask for more information, a demonstration, or a sample unit for your own test.

MIDLAND-ROSS CORPORATION
Owosso Division • Owosso, Michigan

AIR MIDLAND BRAKES

ONE OF THE 400 LARGEST AMERICAN CORPORATIONS



New BORG & BECK 2-Plate "Strap-Drive" Clutches

PACK MORE MUSCLE...WITHOUT ADDED SIZE

Trucks pay out on the road, not in the shop. So it's asking for trouble when a truck engine is too big for its clutch.

To help keep 'em rolling, Borg & Beck has developed a new line of 2-plate clutches with up to 40% greater load capacity . . . yet without any increase in nominal size.

Rated at 500 ft.-lbs. torque capacity, this new Borg & Beck Type 13E2 has 12⅞" O.D. x 7¼" I.D. facings . . . non-cushion rigid or flexible center drive plate . . . space for 16 heat treated coil springs of total load to suit type of service . . . "strap drive" for positive, trouble-free plate separation.

And like all Borg & Beck clutches, Type 13E2 is built to Borg & Beck's pace-setting standards for quality, performance and value. Consult our engineers for details.

BORG & BECK CLUTCH — THE STANDARD

Reg. U.S. Pat. Off.

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THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3

HOW LOUIS ALLIS DOUBLED THE BENEFITS OF SIL-FOS BRAZING

Higher operating temperatures and output demands in electric motors have prompted Louis Allis of Milwaukee, Wisconsin, to switch from soft solder to SIL-FOS 5 brazing on their stator windings. No stranger to SIL-FOS, Louis Allis has brazed rotor end rings for years. Now they get these benefits on both vital parts of their motors:

STRENGTH—The strength of a properly designed and brazed SIL-FOS joint exceeds that of the metals joined. Furthermore, joints do not "creep" even when hot. Here are some typical values:

at 300° F in copper:	30,000 psi.	In brass:	35,000 psi.
at 400° F in copper:	28,000 psi.	In brass:	31,000 psi.

CONDUCTIVITY—Tightly fitted standard lap joints are fully as conductive as copper.

DUCTILITY—SIL-FOS joints have exceptional ductility; enabling them to withstand stresses and strains of vibration, shocks and radical temperature changes fully as well as the metals they join.

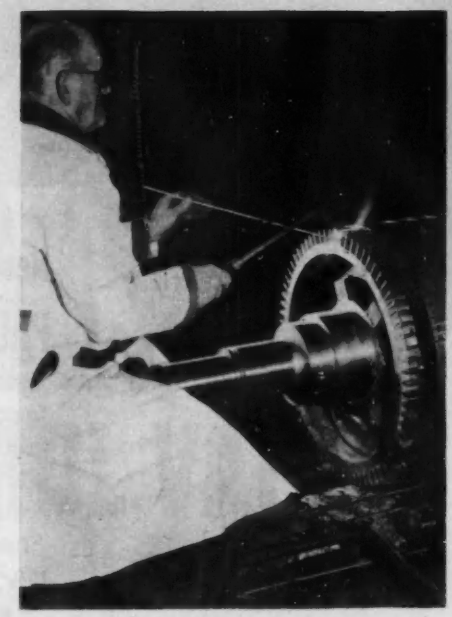
EASY INSTALLATION—FAST PRODUCTION—With SIL-FOS you can get any production you want—you have a choice of heating methods, jigging setups, inspection techniques, etc.

ECONOMY—Low flow point, fast brazing action, reduced labor costs, and vastly reduced reject rate, plus the small amount of alloy needed to make a joint put SIL-FOS in a low-cost category unequaled by other methods.

Alloy	Silver Content %	Type	Starts to flow at °F	°C	Free Flowing at °F	°C
SIL-FOS	15	Wide Melting Range	1185	641	1300	704
SIL-FOS 5	5		1195	646	1300	704

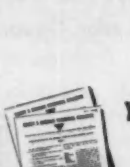
For use in joining ONLY nonferrous metals. Used particularly on copper, brass and bronze. Specially effective in joining pipe and tubing and on electrical work.

Here, operator hand brazes a winding on a motor stator. Increasing motor output requirements demand greater overall operational reliability. With SIL-FOS 5 brazed joints *reliability is assured.*



Rotor ring hand brazing with SIL-FOS has long been the practice at the Louis Allis Co. The success achieved here has been applied to the above with equally excellent results.

Further details on SIL-FOS and SIL-FOS 5 can be had in the form of Technical Literature from Handy & Harman. **Send for Bulletin 20.** Our research and engineering people are ready and willing to help you with any metal joining problem or plan you may have.



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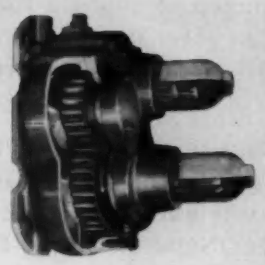
From WARNER AUTOMOTIVE...

Another break through in Power Transmission...

New DUAL RANGE POWER TAKE-OFF ADAPTER

Other Long-Life Factors: Gears and shafts integrally forged from 8620 carburized steel . . . anti-friction bearings . . . high-temperature oil seals.



6-spline shaft gives 540-550 RPM, 21-spline shaft 985-1000 RPM. Protective caps cover shafts when adapter is not in use.

Rated at 30 HP—Momentary Loads up to 40-50 HP

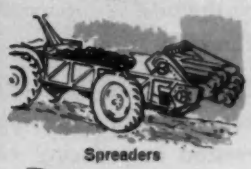
Warner Automotive engineers—the superbly integrated staff that developed Warner Spin-Resistant Differentials and many other advanced power transmission devices—have simplified the operation of tractor-driven agricultural implements. This new adapter can also be built to specification, with shafts operating at almost any RPM, for industrial applications.

Whatever your power transmission problem, consult our engineers without cost or obligation.

FARM APPLICATIONS

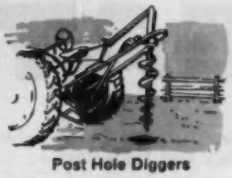
Corn Pickers

Hay Balers



Spreaders

Rotary Cutters



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Transmission Gears • Gear Assemblies • Ring Gears and Pinions • Differential Parts and Assemblies • Splined Shafts

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WARNER AUTOMOTIVE DIVISION

BORG-WARNER CORPORATION

Auburn, Indiana

New Eaton Process Cuts Costs of Alloy-Faced Valves

The new Eaton ECONOSEAT process of applying heat resistant and corrosion resistant material to valve faces makes possible a worthwhile reduction in the amount of costly protective alloys required.

If you have hesitated to use high-alloy-faced valves because of cost—or are now using valves conventionally faced and are interested in reducing costs—you will want complete information about the advantages of Eaton ECONOSEAT Valves. Eaton engineers will be glad to consult with you without obligation.

Call on Eaton engineers to discuss with you the possibilities of applying the ECONOSEAT process to parts, other than valves, requiring protective coatings.

EATON VALVE DIVISION
MANUFACTURING COMPANY
BATTLE CREEK, MICHIGAN

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Gears • Hydraulic Pumps Truck and Trailer Axles • Truck Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

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Look for the beauty of Stainless Steel on your new automobile. Its bright finish will make your car look better, stay in style longer and have a higher trade-in value.

No other metal offers the freedom of design and fabrication, economy of care and the durable beauty that serves and sells like Stainless Steel.

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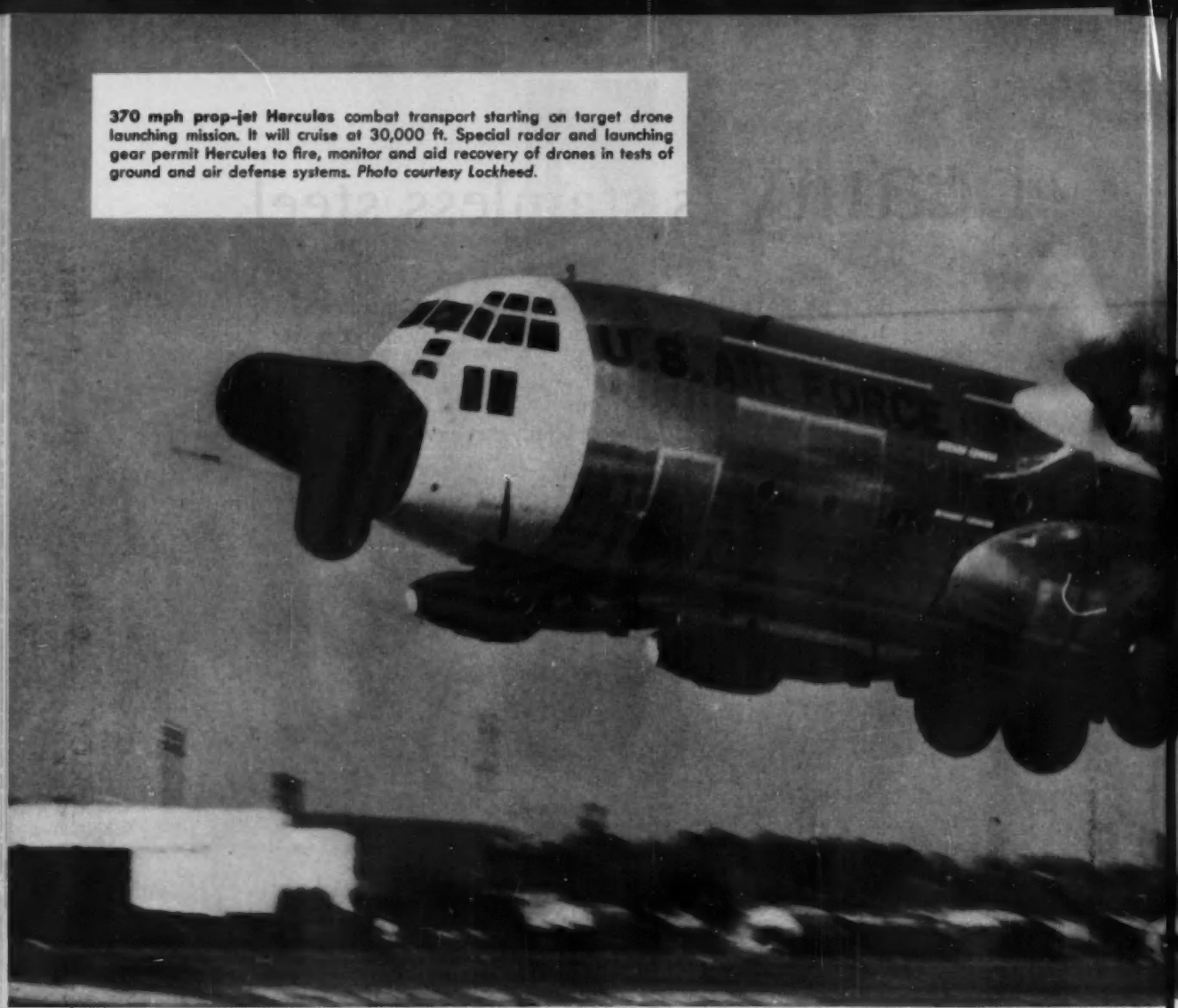
for automobiles



370 mph prop-jet Hercules combat transport starting on target drone launching mission. It will cruise at 30,000 ft. Special radar and launching gear permit Hercules to fire, monitor and aid recovery of drones in tests of ground and air defense systems. *Photo courtesy Lockheed.*

R/M friction piece prolongs landing

Designers of Lockheed's C-130 Hercules, prop-jet assault transport, required a friction material which would help prolong the life of the landing gear guide track. Its use was to face aluminum shoes attached to four main shock struts.

Rigorous tests

Specifications called for a friction material of relatively high bearing strength to withstand ground load stresses of up to 18,000 psi and stable coefficient of friction within a narrow range required to operate against the aluminum track which it would contact.

A wide variety of metal and organic friction materials were subjected to rigorous tests at temperatures to −65°F, in such contaminants or abrasives as mud, dust, tar and ice. The material proved most satisfactory was R/M sintered bronze brazed onto a .010-in.-thick strip of mild steel, a product of Raybestos-Manhattan ingenuity.

A structural adhesive bonds the material to an aluminum shoe at 70 psi with a curing cycle of 1 hour at 350°F. In inspection tests, the bond must show a peel strength of not less than 50 lb. per inch of width.

The aluminum shoe assemblies, faced with the R/M materials, are mounted on air-oil shock struts which serve to support the aircraft on the ground, absorb landing shocks.

Satisfactory performance

Lockheed engineers report that the R/M material has been used in every production model of the C-130 and has delivered

RM
FIRST IN FRICTION

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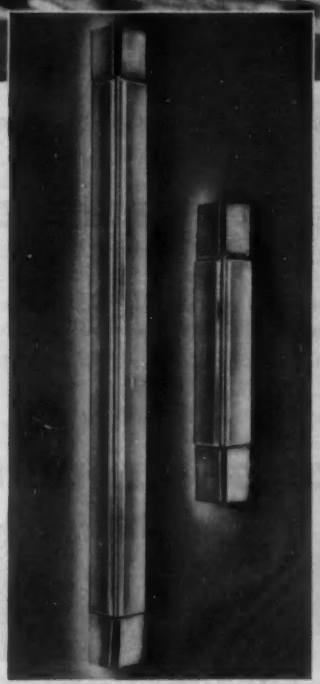
g gear life !

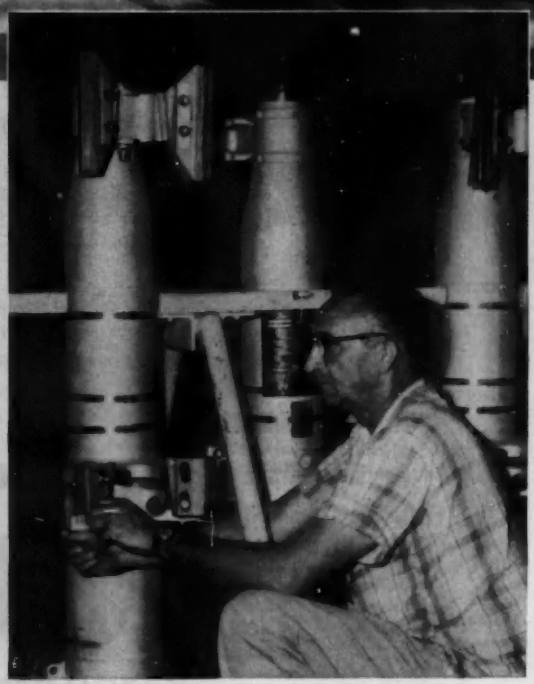
satisfactory performance in this exacting application . . . not one report of excessive wear!

This is another example of the diversity of successful applications of Raybestos-Manhattan friction materials. Why not let R/M's experienced engineers help you solve your friction problems . . . you can always be sure of sound, unbiased counsel on the materials best suited to a given application—for *only R/M manufactures all types of friction materials!* An R/M sales engineer can be at your desk within 24 hours.

Send now for your free copy of Bulletin No. 501 —packed with helpful engineering information on friction materials.



R/M sintered bronze brazed onto .010-in.-thick strips of ½-in.-wide mild steel from these 8¼- and 3-in.-long friction pieces for the Hercules.



Lockheed technician completes installation of landing gear guide shoes onto main shock struts. 16 shoes, each faced with ½-in.-wide sintered metal strip, are used in every production model of the C-130.

The "Long Life" Piston with Cast-Anchored Steel Top Ring Section

CONTINUOUS PERMA-GROOVE*

SUPERIOR PERFORMANCE FOR GASOLINE ENGINES

- ★ HIGHEST WEAR RESISTANCE
- ★ COOL OPERATION
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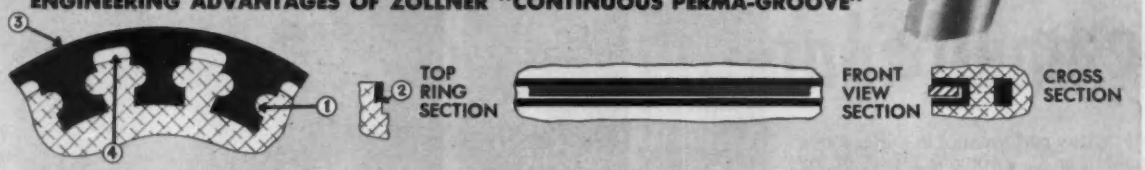
We suggest an immediate test of "Continuous Perma-Groove" advantages for your gasoline engine.

ENGINEERING ADVANTAGES OF ZOLLNER "CONTINUOUS PERMA-GROOVE"



1. Cast-anchored—no bimetal expansion problem.
2. Dovetailed edges keep insert securely in place.
3. 100% steel bearing area for wear resistance.
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5. Light in weight.

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ZOLLNER PISTONS

THE ORIGINAL EQUIPMENT PISTONS

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ROADRANGERS cut trip time and maintenance for CXI

Chicago Express, Inc., New York City, emphasizes fast, safe, dependable service on its runs between the New York area and major Midwest cities. Typical of the performance of CXI's fleet is the 52-hour round trip between Bound Brook, New Jersey, and Chicago.

Backbone of the company's Midwest service are 20 White 9000 Tractors equipped with 190 and 220 hp diesel engines and 10-speed Fuller R-960 ROADRANGER Transmissions. Fleet Superintendent Michael Governale says, "We've cut 3½ to 4 hours from our Chicago run with the ROADRANGER-equipped units. Other transmissions we've used do not compare with the ROADRANGER for upkeep, easy shifting and overall performance. For our operation, I don't think there's a better transmission than the Fuller ROADRANGER."

Fred Hoette, Vice President in Charge of Maintenance, adds, "We endorse the Fuller ROADRANGER 100%. In contemplating new equipment, we are definitely specifying Fuller Transmissions."

Ask your dealer for full details about the Fuller ROADRANGER best suited to meet the requirements of your particular operation.

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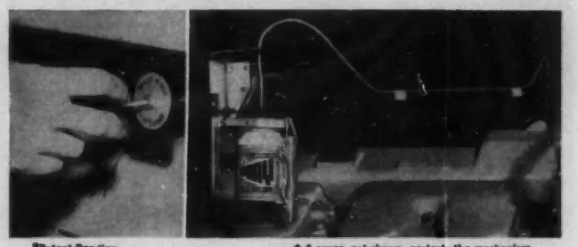
STARTS COLD DIESEL & GASOLINE ENGINES INSTANTLY!

INSTNSTART insures quick starts for cold diesel and gasoline engines all year 'round. (Until an engine reaches normal operating temperature it is a cold engine.) The driver or pilot pulls a knob at his fingertips releasing enough fluid necessary to sustain combustion regardless of weather conditions. INSTNSTART APPLICATORS employ our economical pressurized can of Spray Starting Fluid. This safe, convenient, closed system has been well received in the U. S. and abroad. Quicker starts with INSTNSTART eliminate down-time and prolong engine and electrical system life. It can be installed in minutes with a screwdriver and drill.



*Patent Pending ▲A cover, not shown, protects the mechanism.

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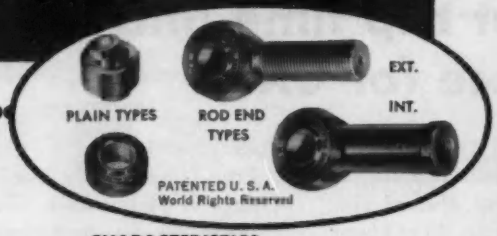
"Monoball"
SELF-ALIGNING BEARINGS



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1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
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Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. SAE59

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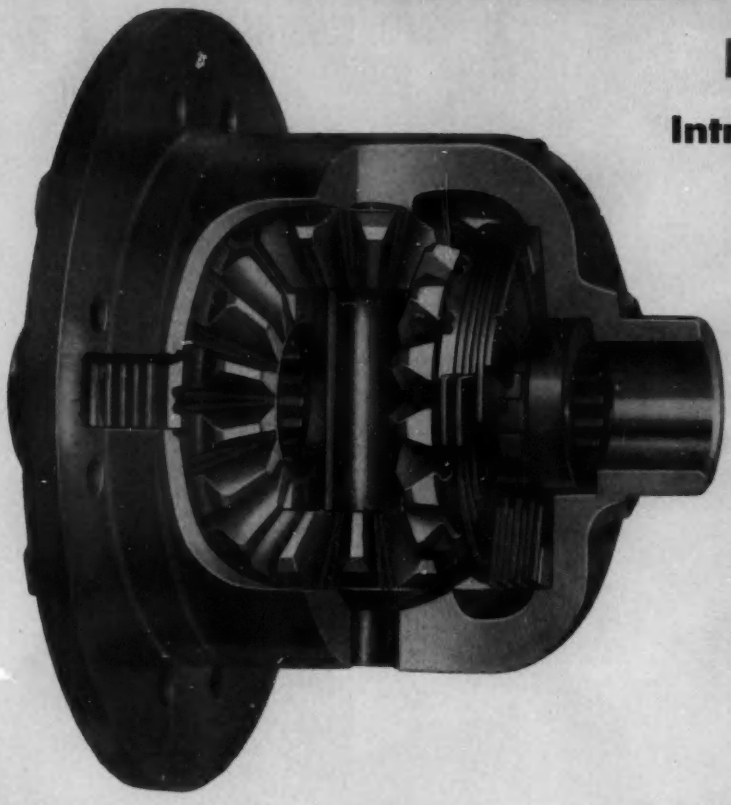
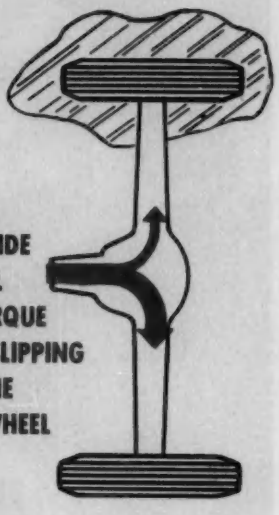
The New TRAC-AIDE DIFFERENTIAL by EATON

Introduces Long-Awaited Design Features





THE TRAC-AIDE DIFFERENTIAL DIVERTS TORQUE FROM THE SLIPPING TO THE GRIPPING WHEEL

The TRAC-AIDE Differential by Eaton is a conventional differential, plus a simple non-locking, multi-disc friction clutch which automatically engages to retard motion of the slipping wheel, and provides smooth, chatter-free transmission of torque to the wheel with the greater traction.

The secret of the Eaton TRAC-AIDE Differential is the coefficient of friction designed into the clutch discs. This provides a stable, durable bias ratio that assures chatter-free operation without the use of special lubricants. With fewer parts and one-piece case, this economical unit is easily adapted to varied axle designs for cars and small trucks.

The Eaton Differential makes a distinct contribution to more dependable vehicle operation. We will be glad to discuss the unique design feaures of this new Eaton Differential with your engineers.

ONLY EATON TRAC-AIDE OFFERS ALL OF THESE ADVANTAGES

No Cams
•
One-piece Case
•
Few Parts
•
Easy Maintenance
•
No Lock-up Peaks
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Exclusive Long-Life Disc Design
•
No Special Lubricant Required

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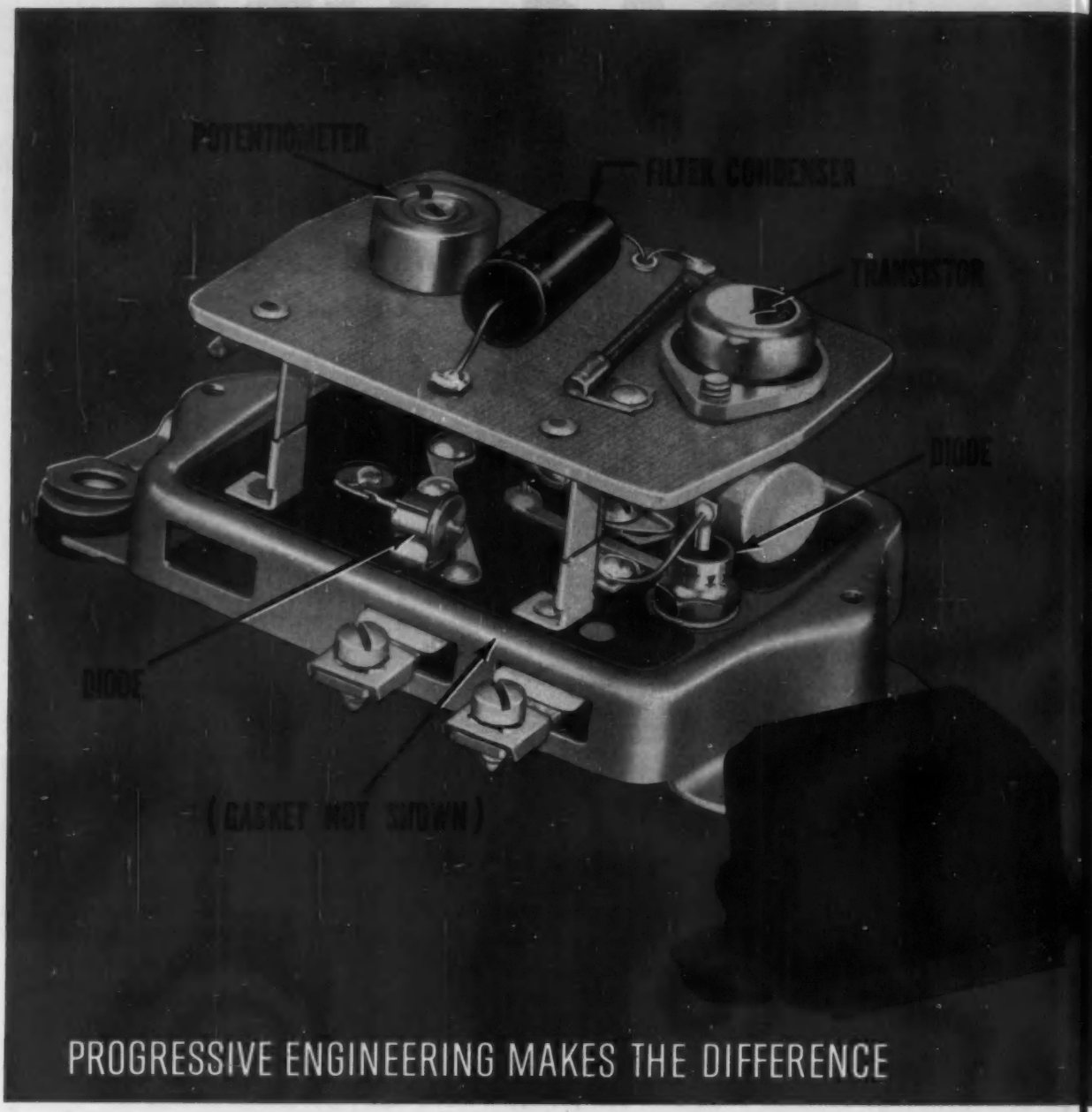


PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE

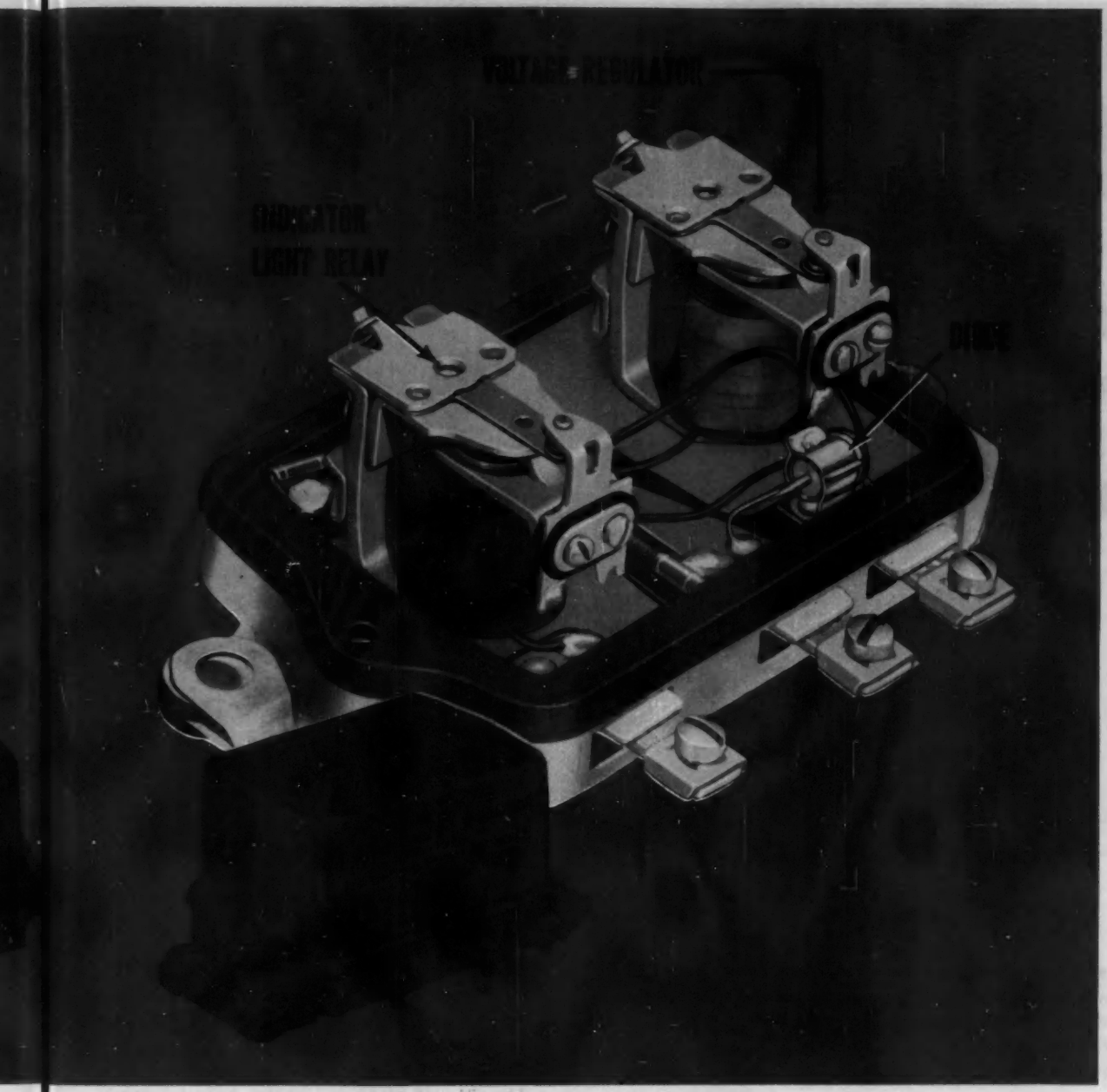
ONLY DELCO-REMY OFFERS FULL-TRANSISTOR

Designed for use with DELCO-REMY'S new self-rectifying a.c. generators

Now you can choose between *two* modern new Delco-Remy regulators—the most accurate available today. One is a full-transistor model, the other transistorized.

The FULL-TRANSISTOR REGULATOR has no moving parts and offers the ultimate in accurate electrical performance, durability and reliability. It is composed entirely of transistors, diodes, condensers and resistors, permitting higher field current for better generator performance. Constant voltage control is unaffected by temperature changes, vibration, or mounting position. A simplified external adjusting feature permits easy voltage setting for varying operating conditions. And this full-transistor regulator requires no periodic servicing.

The TRANSISTORIZED REGULATOR contains a single transistor and diode working in conjunction with a vibrating-type voltage sensing unit. The transistorized circuit



AND TRANSISTORIZED VOLTAGE REGULATORS

permits high field current for improved generator performance with low non-inductive current through the contacts for greatly extended contact life. Models are available for circuits containing either ammeters or indicator lights. All units are temperature compensated to better match battery voltage requirements.

Both the full-transistor and the transistorized models have the same mounting dimensions as standard regulators.

Whichever model you choose for your new vehicles or for replacement on present ones, you can be sure of reduced servicing and extended battery life. Available from your car or truck dealer or through the United Motors System.

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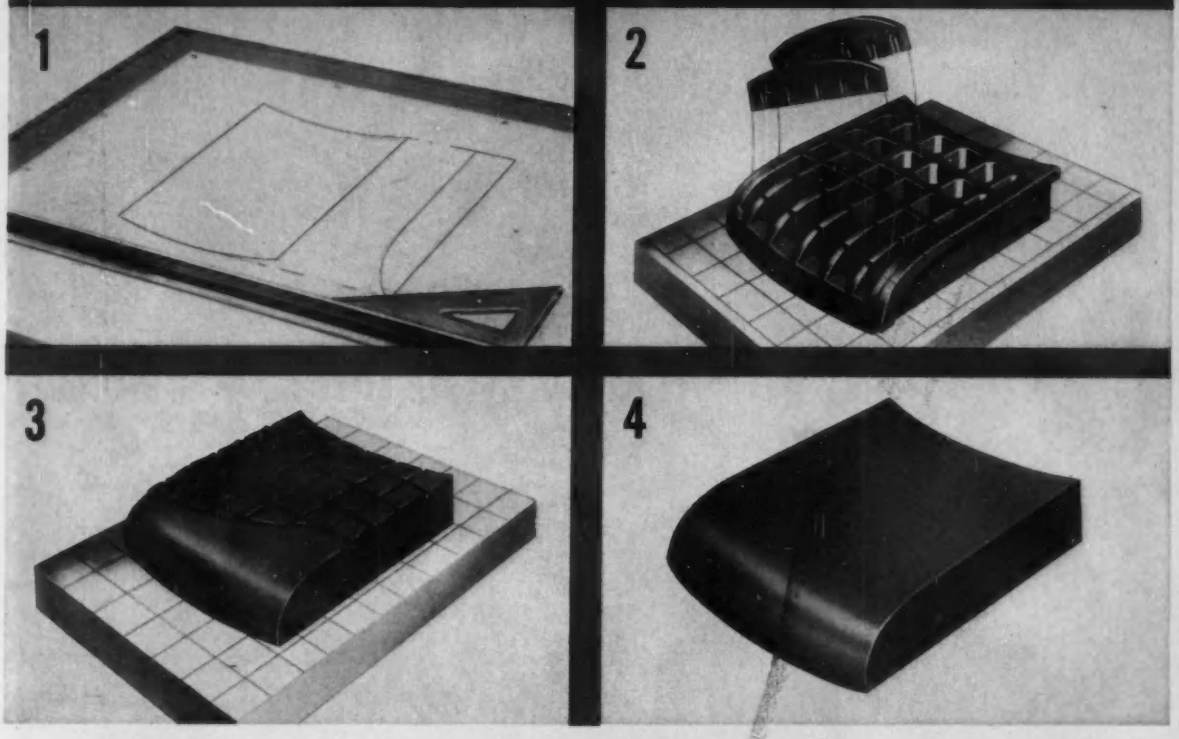
NOW! A FAST, ECONOMICAL METHOD FOR MAKING MASTER MODELS



. . . developed by Kish Industries using

RCI EPOXY RESINS

• Master models are made faster and better using this new Kish process* made possible by a completely different type of epoxy formulation — based on RCI EPOTUF epoxy resins.

Here, briefly, is how the Kish system works:

(1) Starting with the draft or styling print, templates are cut from pre-cast KiPlaBoard (fully-cured epoxy board made in varying thicknesses).

(2) These templates are bonded into an "egg crate" having the general shape of the model.

(3) The open areas of the "egg crate" are filled with Kish No. 44 Resin Compound (formulated with RCI EPOTUFS) and after the compound cures the rough model is shaped and finish-surfaced using standard woodworking techniques.

(4) The finished model is grain-free, dimensionally stable, and unaffected by moisture and weather. It will not chip or deteriorate with age and can be altered simply by bonding additional Epotuf-based material on the model.

This remarkable Kish innovation is just one of a constantly growing number of jobs done more efficiently and economically with versatile RCI EPOTUF epoxy resins.

Complete information on the Kish System is available from Kish Industries, Inc., 1301 Turner Street, Lansing 6, Michigan.

Creative Chemistry
...Your Partner in Progress

RCI **REICHHOLD**

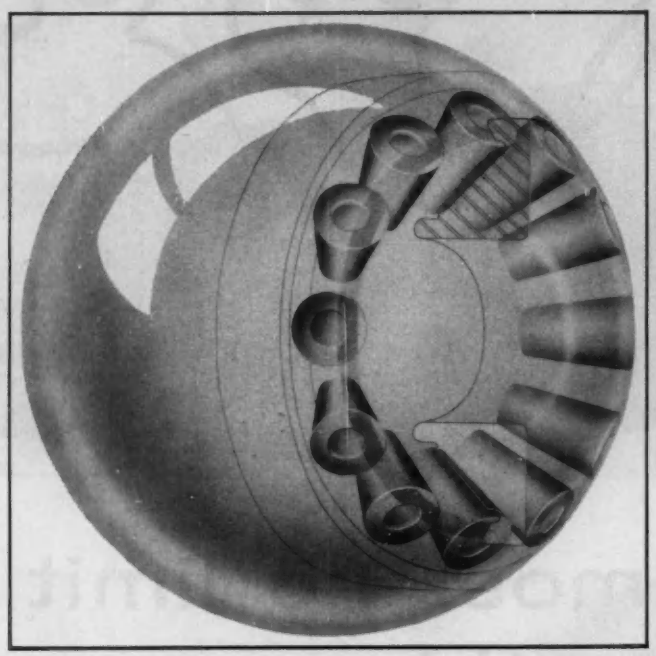
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

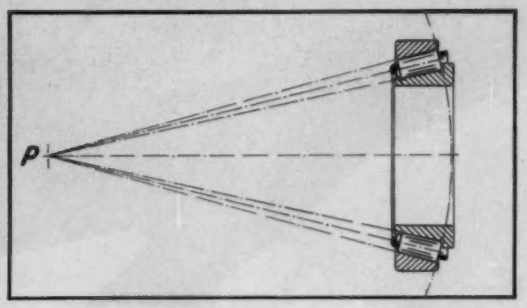
One in a series of technical reports by Bower

BEARING BRIEFINGS

SPHERICITY — ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

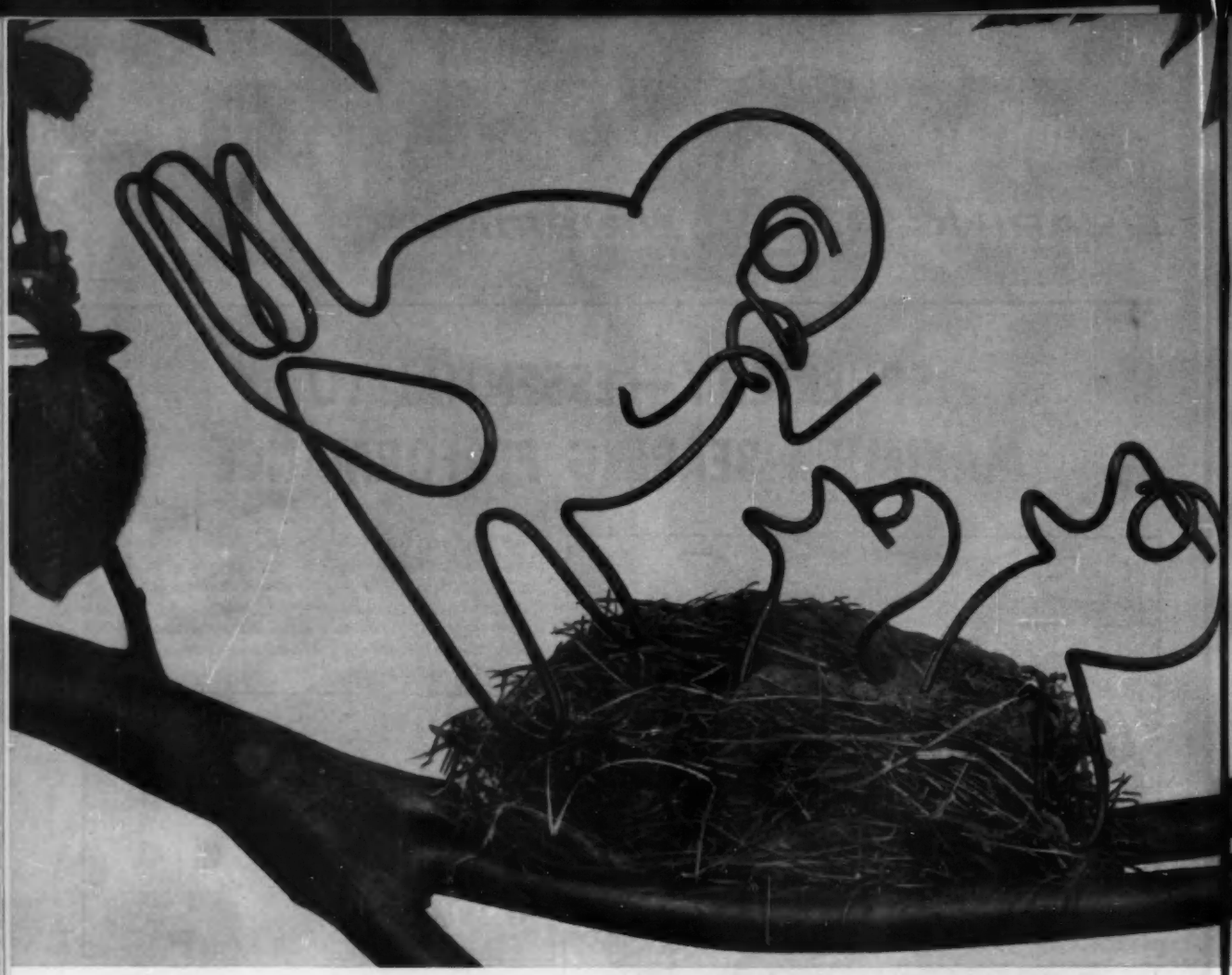
As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

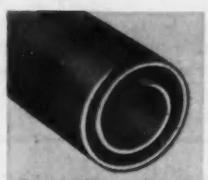
In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

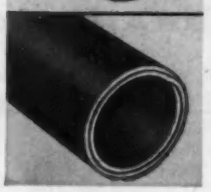
BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



There's almost no limit to the things Bundy can mass-fabricate



Bundyweld is the original tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.



Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

Whether it's a complex shape, or just a simple bend, Bundy knows virtually no bounds when it comes to mass-fabricating steel tubing. You see, Bundy engineers are tubing specialists . . . backed by never-ending, ever-bending experience. And here are just a few of the benefits you will derive.

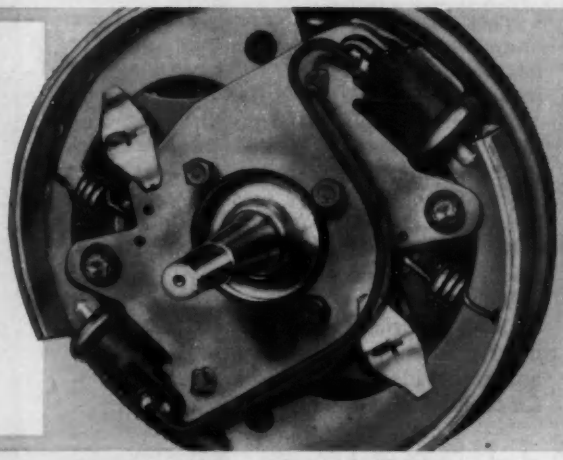
From a single strip of steel comes double-walled, copper-brazed Bundyweld® tubing—leakproof by test—and the tubing standard of the automotive industry. In fact, Bundyweld steel tubing is used in many applications in 95% of today's cars.

At any stage of product development, Bundy designers can be called in for consultation, and suggestions of time- and money-saving modifications.

For low unit-cost and uniformly high quality, Bundy-designed fixtures and machines are geared to mass-fabricate parts to *your* specifications. Covered by Government Spec. MIL-T-3520, Type III.

Got a tubing problem? Better see Bundy *first!* Phone, write, or wire Bundy Tubing Company, Detroit 14, Michigan, today.

Another example of Bundy mass-fabrication. This internal hydraulic "snake" replaces mechanical brake linkage; provides safer, surer stopping. Double-walled Bundyweld steel tubing wears indefinitely; with high resistance to vibration fatigue.



There's no substitute for the original

BUNDYWELD® TUBING

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

BUNDY TUBING COMPANY • DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

DYNAMIC DIFFERENCE
in hydraulic performance

Webster
DIRECTIONAL CONTROL VALVES

Combines to culvert cleaners — anywhere one, two or more hydraulic applications are handled at one time... *the difference is dynamically apparent when Webster is on the job!* Versatile! Parallel design permits control of up to 6 independent circuits. Range! Operating pressures to 2000 psi — shock pressures to 5000 psi. Lowest back pressure. Compact! Smallest size for rating. Three sizes — single spool type in 20 gpm capacity, parallel stacked in 20 and 40 gpm capacities.

You find Webster Directional Control Valves on leading agricultural, road building and industrial machines. Chances are there's a size and model ideally suited for your product — for the dynamic difference that pays!

DESIGNED FOR PEAK PERFORMANCE

- Alloy steel spools — heat-treated, precision-ground.
- Fully balanced at all pressures.
- Stack valves have throttling grooves in spools for smooth, gradual flow.
- Inlet and outlet connections can be made to the same end of the valve assembly to simplify hook up.
- Alternate porting positions provided for flexibility in application.

Call the man from Webster

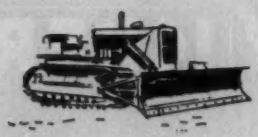
... he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

BULLETIN HY1 gives complete performance and installation data.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

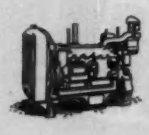
our 50th year **RACINE · WIS**



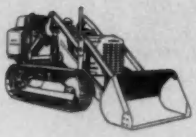
Challenging Engineering Opportunities at CATERPILLAR

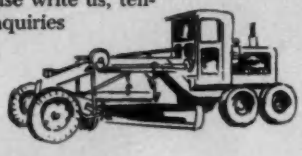
be a part of the company building the world's most complete line of earthmoving equipment

Find the satisfaction of *growth* and *stability* within a *growth* company — where imaginative men are creating products for highway construction — industry — farms — national defense — products which build a better world.



Caterpillar offers top ranking Research and Development opportunities — stimulating assignments — professional and personal advancement. You'll associate with the leaders and pioneers in this field — and have at your command the finest equipment, laboratories and development facilities. Please write us, telling all about yourself. Inquiries are confidential, of course.





(Below — New Caterpillar Technical Center presently under construction)

responsible positions available in
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GAS TURBINE LABORATORY
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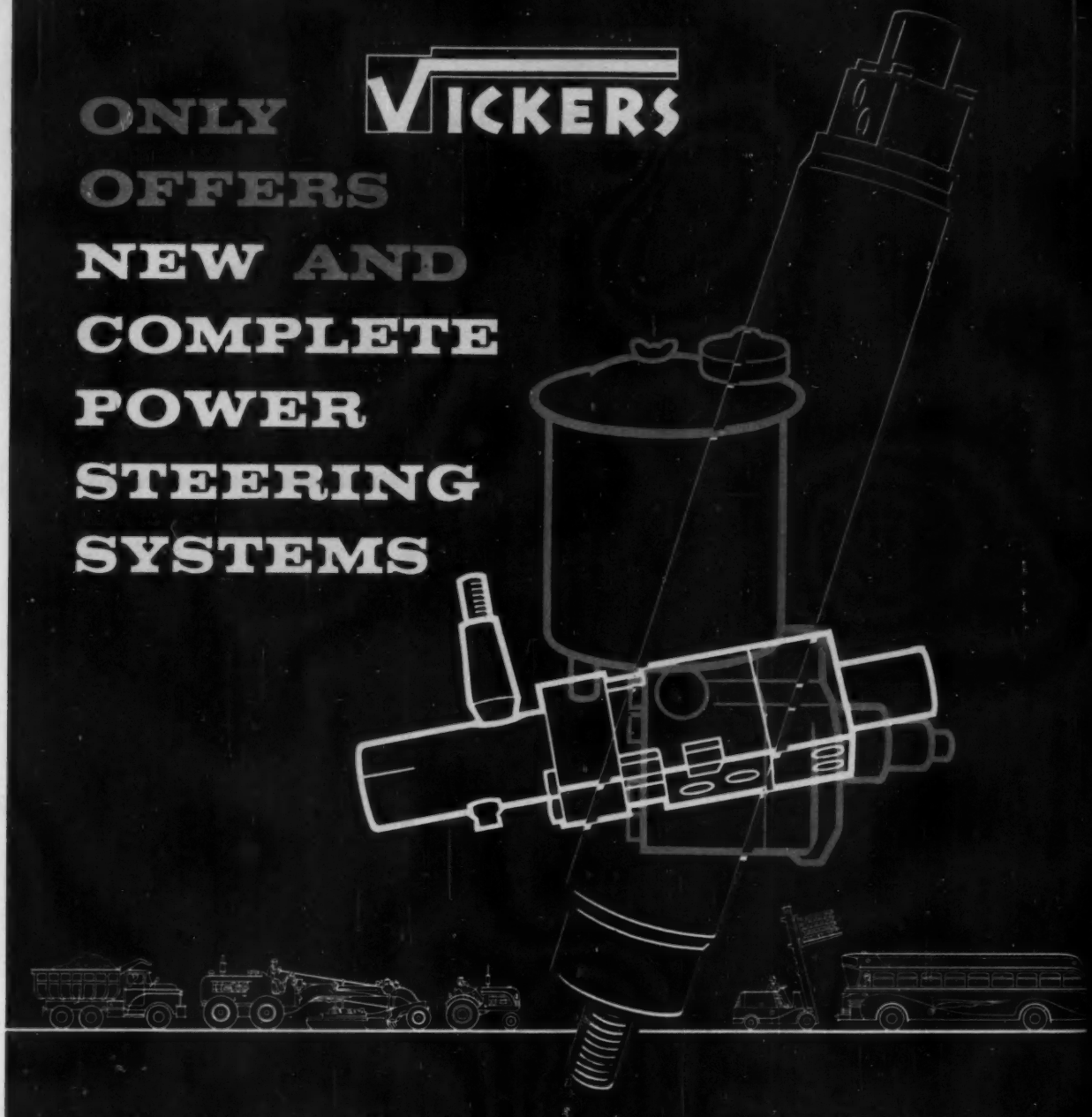
SEND RESUMÉS TO:
John A. Myers—SAEJ-119
Professional and Technical Employment

CATERPILLAR TRACTOR CO.
PEORIA, ILLINOIS

ONLY VICKERS OFFERS NEW AND COMPLETE POWER STEERING SYSTEMS



Complete System Responsibility

VANE PUMPS FOR BEST OPERATION

The Vickers power steering system utilizes vane pumps designed and built to last much longer than other type pumps. Further, they exert virtually no load on the starter like gear pumps do on those cold morning starts.

WORLDWIDE STOCKS AND INTERCHANGEABILITY

If part of your production goes into export, or if you manufacture abroad, consider this: Vickers products are built in plants throughout the free world . . . and all parts from all plants are completely interchangeable. Wherever your equipment is working, there are Vickers parts nearby.

FOR ALL THE DATA . . .

New bulletin gives complete information on this important breakthrough in power steering design and manufacture. It contains dimensions, ratings and other data so you can draw your own comparisons. Write for Bulletin M5110.

For axle loadings from 1,500 lbs. to 128,000 lbs.

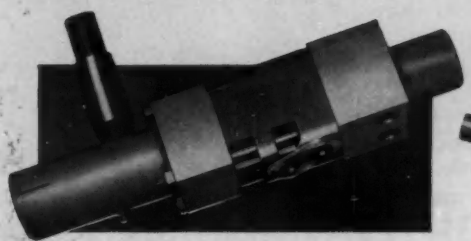
Manufacturers of mobile equipment can now install a completely tailor-made power steering system using standard, production built components. These components are designed to occupy less space because of compact design and high pressure operation (up to 2000 psi). Size for size you get double the thrust for equivalent price.

There are other advantages, too. Your engineering and manufacturing costs are substantially reduced since for all vehicle models you have a matching standard system. Your inventory is reduced because fewer parts are needed and all parts are interchangeable... field service is simplified, speeded, too. These parts are all of the same well-engineered construction providing uniform performance and service.

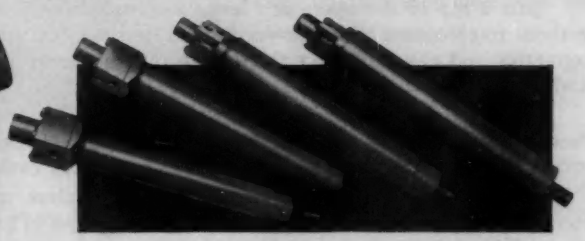
All cylinders are double walled eliminating functional damage to cylinder walls by flying debris, a common hazard.

In addition, when you deal with Vickers you are dealing with a pioneer in power steering... a company that maintains a staff of specialists in power steering to serve you. AND, you get the *complete* system from one source... Vickers, the name that *makes* the news in fluid power.

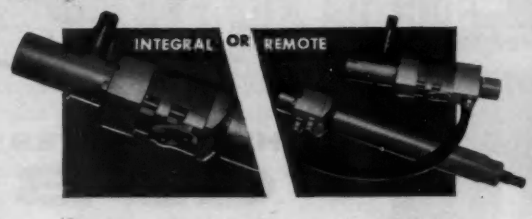
FOR ANY VEHICLE HERE'S HOW SIMPLE IT IS



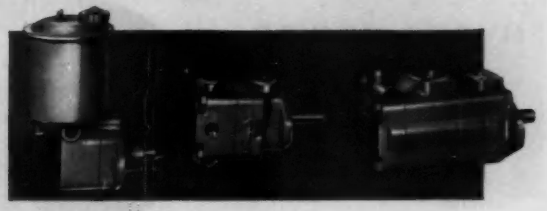
1. You take this **ONE** valve



2. One of **FOUR** cylinders



3. Connect them like this



4. Add one of three pumps

and you have TAILOR-MADE VICKERS® POWER STEERING with STANDARD PRODUCTION-BUILT COMPONENTS

8182

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PEAK POWER OUTPUT FOR HEAVY-DUTY EQUIPMENT...

HYDRA-DRIVES®

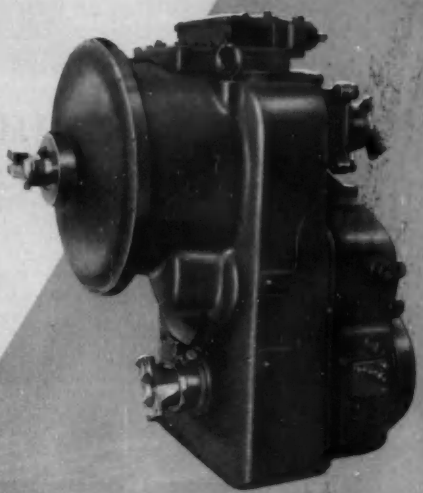
POWER SHIFT TRANSMISSIONS and TORQUE CONVERTERS

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts without interruption of the power flow. Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

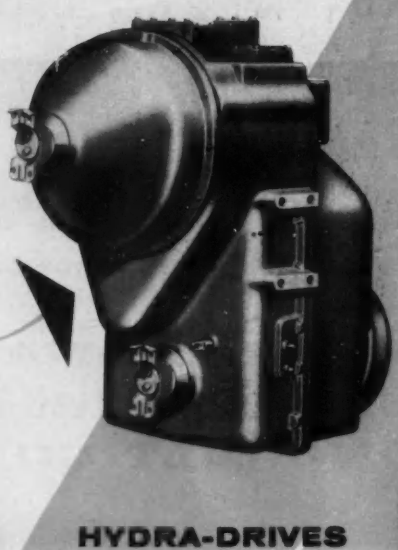
With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.



HYDRA-DRIVES BDB Transmission

- Four speeds forward and reverse.
- Full power shifting.
- For equipment up to 175 h.p.



HYDRA-DRIVES CDB Transmission

- Four speeds forward and reverse.
- Power shift in each range both forward and reverse.
- For equipment up to 250 h.p.

HYDRA-DRIVES Torque Converter

- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
- For vehicles up to 500 h.p.

HYDRA-DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

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TORQUE TALK ABOUT CLARK® EQUIPMENT

WORLD'S WINNINGEST HORSE protected by Clark Air Ride

This horse rides in regal style—and why shouldn't he? He's Round Table and he's won over $1,500,000 so far in his racing career—more than any horse in history. His "chariot" rides smoothly on Clark Air Suspension.

This Suspension was chosen by the trailer manufacturer, Aluminum Body Corporation, Montebello, California, principally to swallow the shocks of high-speed travel. Clark Air Suspension also controls sway on curves . . . automatically keeps trailer level when loads are unbalanced . . . prevents "wheel-hop" when stopping.

If you haul fragile cargo of *any* kind—horses or precision instruments, cameras or cookies—it will pay you to investigate Clark Air Suspension. Besides load protection, you'll get the pluses of lighter vehicle weight . . . less maintenance . . . and longer tire life. Drop us a postcard for full details.

TESTS FOR U.S. NAVY SHOW CLARK AIR RIDE CUTS ROAD SHOCK 70%

When the U.S. Navy put together this traveling air training "school," some method of protecting a trailer full of delicate machines and instruments had to be found.

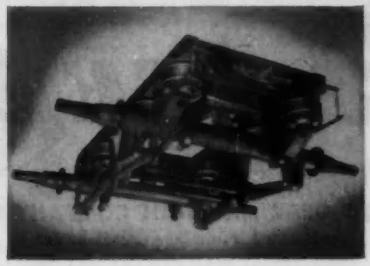
The Navy selected a trailer built by The Gerstenslager Company with Clark Air Suspension.

This choice was made after painstaking road tests had shown that a trailer equipped with ordinary leaf

springs transmits up to 5½ "g's" of shock to the cargo. Coil springs cut this "bounce" to 2½ "g's". Clark Air Ride reduces it to 1½ "g's", well within the margin of safety desired by the Navy engineers and less than any other air suspension tested.

CLARK AIR SUSPENSIONS

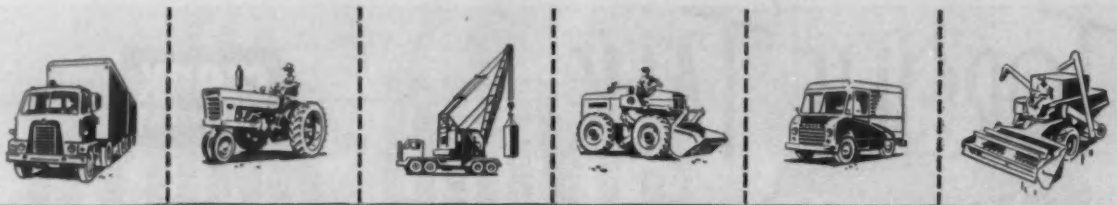
come as complete packages, ready for installation on new or in-use semis, in single or tandem units. Each "package" includes the frame structure, air springs, shock absorbers, torque rods, radius rods, air protection filters, and leveling valves.



For Further Information

and full details on any of Clark's automotive components, simply address a card or a call to:

CLARK EQUIPMENT COMPANY
AUTOMOTIVE DIVISION
Buchanan, Michigan



Ross variable ratio steering has been proved in service by 31 of today's vehicle manufacturers ... including 9 of 13 makers of heavy-duty trucks

● Ross variable-ratio steering gives faster steering and quicker recovery for turns . . . and slower steering and greater stability for straight-ahead handling. Ross invites *your* inquiry.

Ross STEERING

ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA
Gemmer Division • Detroit

Diversified electromechanical systems capability

AiResearch Actuation Systems For Portable Radar represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.

U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

THE GARRETT CORPORATION

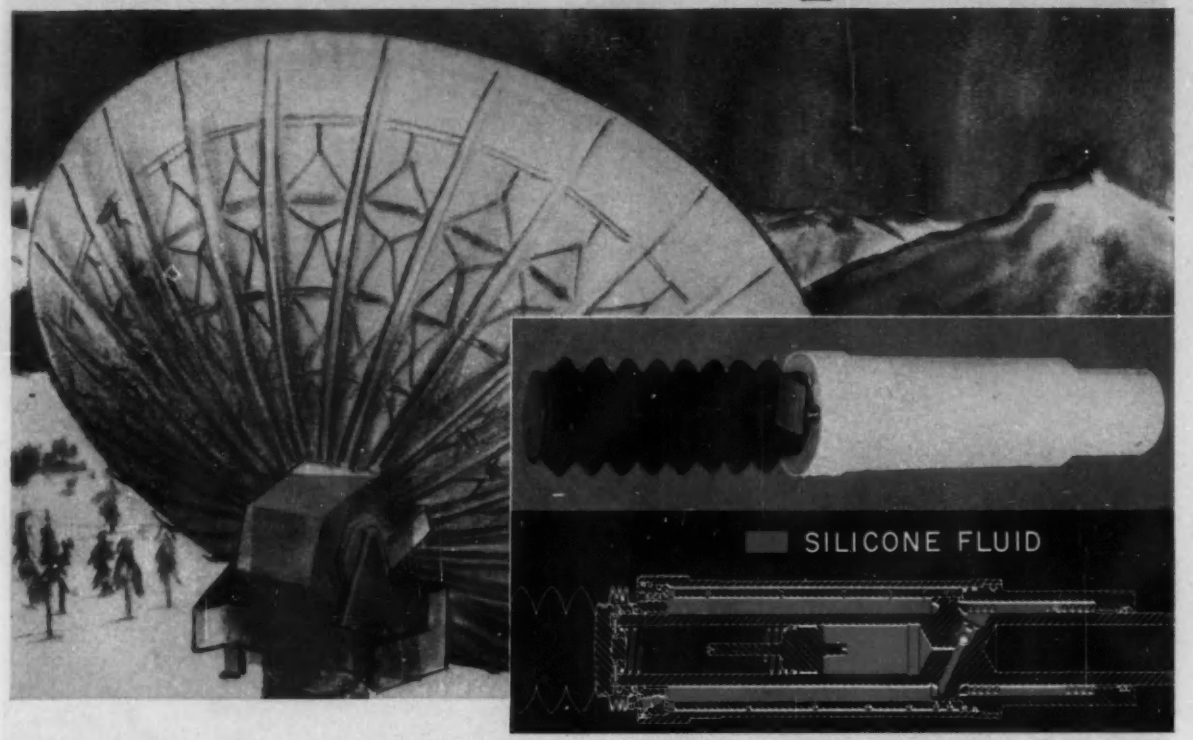
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

SILICONE NEWS from Dow Corning

Silicones Soak Up Shock



Dow Corning Damping Fluids Unaffected by Cold, Heat, Time

"Steady-state" fluids — that's what some engineers call these exceptionally stable damping media. And steady they are. Their useful range extends from as low as —100 F on the cold side to over 400 F on the hot side! Within these extremes, viscosity varies but little. They're resistant to oxidation and to breakdown under shear; won't sludge; won't corrode metals. Because of such properties, silicone fluids are highly effective media for damping, springing and torque converting.

Illustrated above is one example. It's a Radar Antenna Buffer, designed and built by Houdaille Industries, Buffalo, N. Y. Radar equipped with this unit, "Has silicone; won't over-travel." For that's where the buffering comes in. When the antenna swings to its travel limit, something must give, or the structure may be shock-damaged. What "gives" is the Buffer, and the working medium is Dow Corning silicone fluid. Because the damping fluid's viscosity is unaltered by temperature changes, performance of the Buffer varies less than 1% per 100 Fahrenheit degrees. That's important, because installations of ballistic missile early warning radar, which use the Buffer, may vary from tropic to Arctic.

This is but one of many designs where silicone fluids have aided the product engineer. Others include auto fan drives, aircraft oleo struts, missile accelerometers, and truck scales. If in your design you require a high performance damping or coupling fluid, investigate Dow Corning Silicones . . . the fluids with "steady-state" viscosity. Write to Dept. 9123 for more detailed information.

TYPICAL PROPERTIES OF DOW CORNING 200 FLUID*

Centistokes at 25 C	Pour Point, °F	Visc/temp.[1] Coefficient	Coeff. of Expansion cc/cc/°C
10	—85	0.57	0.00108
50	—67	0.59	0.00104
100	—67	0.60	0.00096
500	—58	0.62	0.00096
1,000	—58	0.62	0.00096
12,500	—51	0.58	0.00096

*Available in a range of viscosities to over a million centistokes.

[1] $1 - \frac{\text{Viscosity at 210 F}}{\text{Viscosity at 100 F}}$

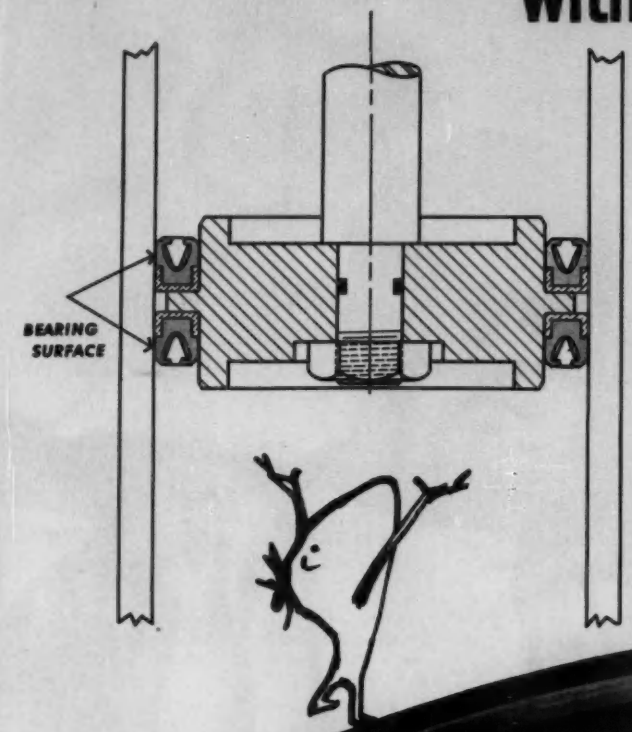
Your nearest Dow Corning office is the number one source for information and technical service on silicones.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

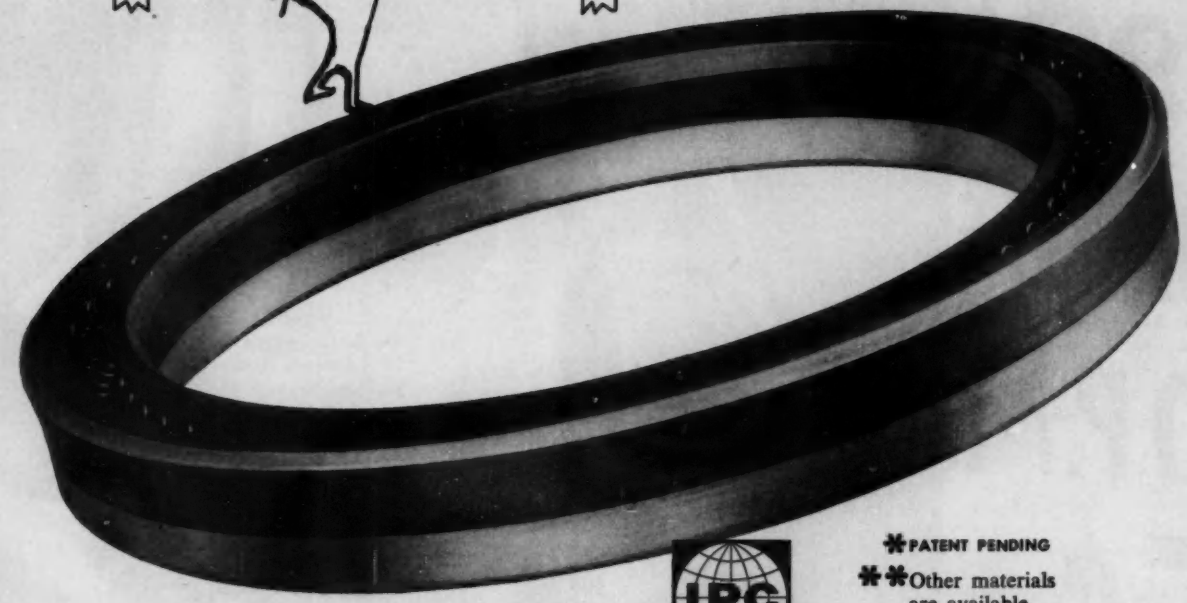
Squeeze down on expensive U-Packing Assemblies . . . with IPC's revolutionary "GUIDE-U-PAK"*. . . the packing with a built-in bearing!



A new engineering concept for hydraulic systems sealing! . . . IPC's GUIDE-U-PAK is a bonded case U packing that really puts the squeeze on expensive, complex U packing assemblies. Follower plates or back up plates with their high cost drilling, machining and fitting are eliminated. *Moreover,* GUIDE-U-PAK supplies its own bearing . . . riding smoothly on a close tolerance brass**case. You can end the practice of machining a wear sleeve on the piston surface, too! GUIDE-U-PAK is press fitted on the piston.

The "custom approach" in packings and seal manufacture, which typifies all IPC products, has brought this development through extensive testing. Precise manufacture means that you can specify critical tolerances for both ID and OD measurements or we will be glad to analyze your problem . . . recommend specific sizes. By establishing these limitations you can be assured of exact bearing surface and press fit.

For your next hydraulic sealing problem investigate GUIDE-U-PAK. You'll be pleasantly surprised!



OIL SEALS / PACKINGS / PRECISION MOLDING

Custom designed for your application . . .

IPC

*PATENT PENDING

**Other materials are available. Write for details.

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

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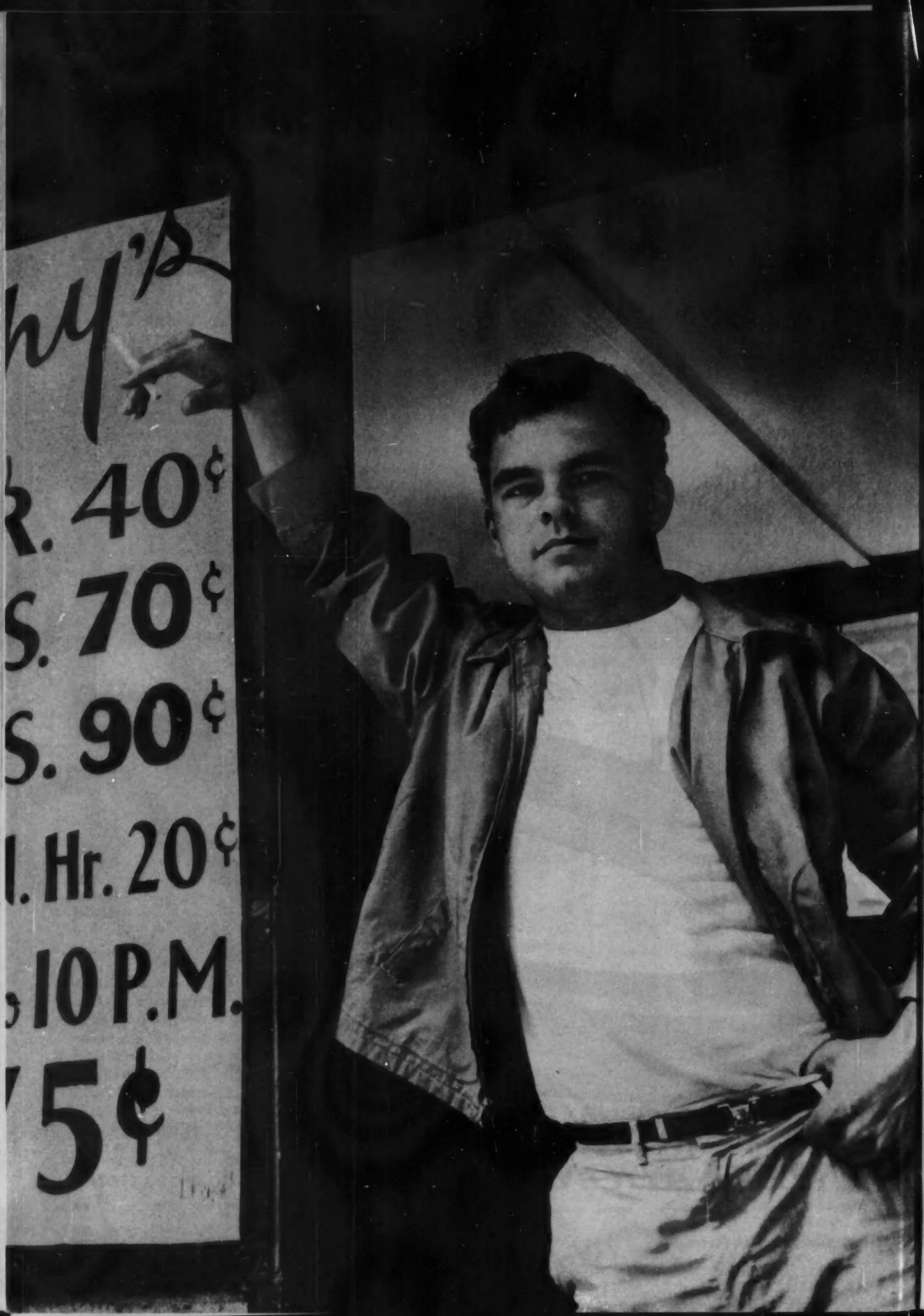
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S. 70¢
S. 90¢
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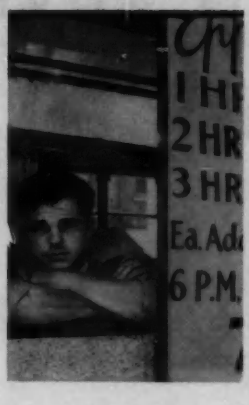

"Stainless Steel is the best thing that ever happened to auto trim . . . and the parking lot industry,"

says Jackie Roller, Parking Attendant, Eppy's, Pittsburgh, Pa.

Q. *Mr. Roller, do you feel qualified to comment on Stainless Steel auto trim?*

A. Well, I've been knocking around in this business for eight years now and I pretty well know all the wrinkles.

Q. *And what do you think about Stainless Steel?*

A. Stainless Steel is the best thing that ever happened to auto trim.

Q. *How would you compare it to other trim materials?*

A. It's stronger.

Q. *You mean Stainless Steel trim isn't a decoration that's going along for the ride . . . it adds to the structural strength of the car because Stainless is so strong?*

A. . . . yes.

Q. *And what about the much greater hardness of Stainless Steel?*

A. *Much* harder.

Q. *Doesn't the extreme hardness of Stainless Steel trim make it more resistant to dents and scratches that would mar other trim materials?*

A. Yes. It's the best thing that ever happened to us parking attendants. You should hear how . . .

Q. *What about the overall appearance of Stainless Steel trim?*

A. Very nice.

Q. *We mean, doesn't the hardness and corrosion resistance of Stainless Steel keep it bright and clean for years?*

A. Yes.

Q. *Doesn't Stainless Steel have a deep, jewelry-like luster that far outclasses any other trim material?*

A. Yes . . . far.

Q. *Don't you feel that the luster of Stainless Steel bespeaks taste instead of gaudiness?*

A. Yes.

Q. *Now, do you feel that even though Stainless is a little more expensive than other trim materials, it will often actually save money for car manufacturers?*

A. Yes . . . Well, no, I never felt that.

Q. *Well, don't you feel that because of its greater strength and hardness, manufacturers don't have to overdesign with Stainless Steel? Won't a little bit of Stainless Steel look better, work harder, and cost less than a lot of weaker metals? And because Stainless is easy to fabricate, won't it save money in production—for example, replace more expensive die castings with Stainless Steel stampings?*

A. Yes.

Q. *Would you say that these advantages —strength, hardness, appearance, formability, and economy—are reasons why manufacturers use more and more Stainless Steel trim every year . . . and why dealers and buyers are glad they use more?*

A. Yes.

Q. *Thank you, Mr. Roller.*

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American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
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United States Steel Export Company

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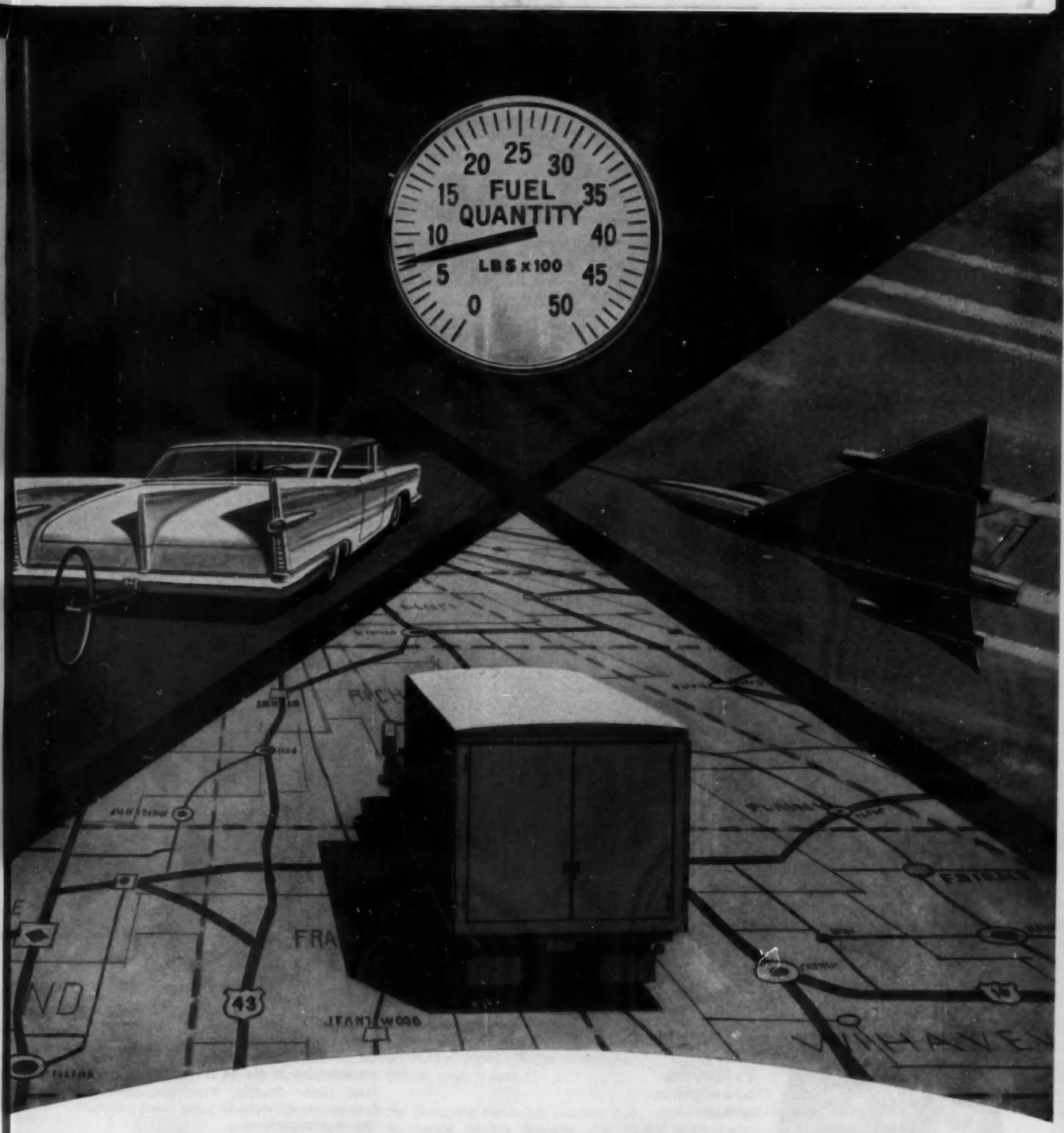

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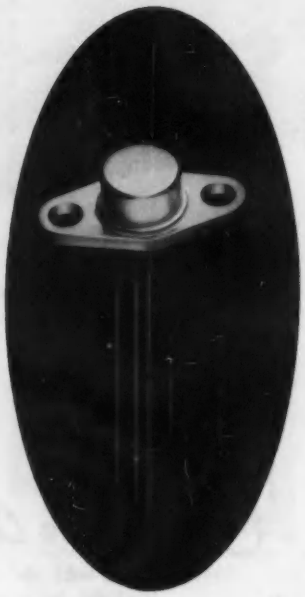

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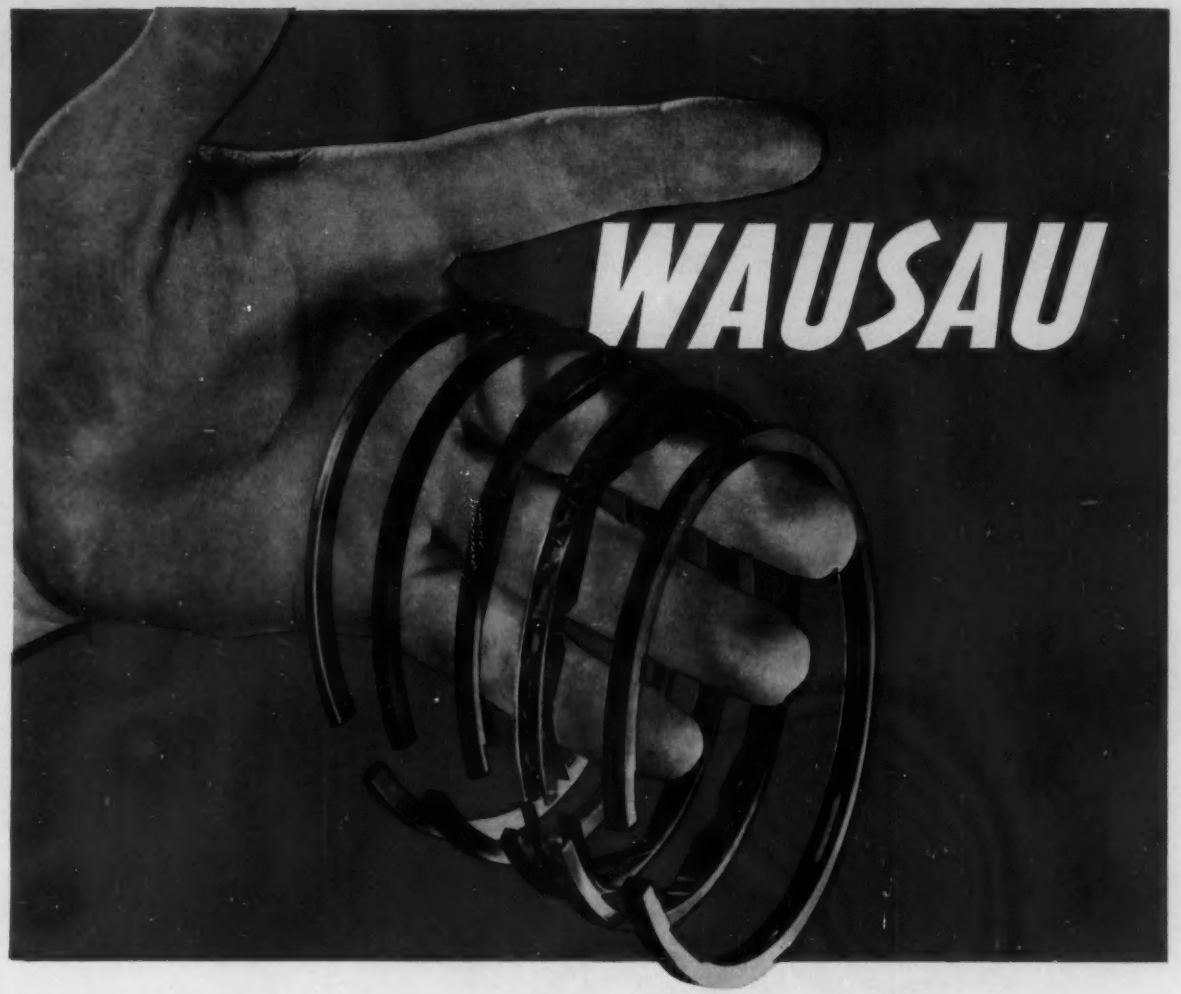
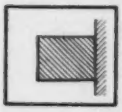
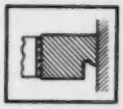


How to select a set of rings for heavy-duty engines

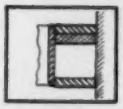
Top Ring — Should be specially alloyed for high impact resistance and fatigue and wear resistance. Example: WAUSAU HT-100 TORSIONAL COMPRESSION (Available in all standard compression ring types).



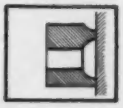
Second Ring — Should be designed for quick seating but with proper tension to insure proper blowby control and drag-free operation. Example: WAUSAU TAPER FACE COMPRESSION.



Scraper Ring — Scraper ring must be specially designed for proper balance between blowby and oil control functions (may be used with inner spring if desired). Example: WAUSAU SUPER SCRAPER.



Oil Ring — Should be scuff-proof and seat quickly. Multiple piece design should include center section designed to dissipate heat and prevent clogging. Example: WAUSAU OILSAVR, the free-running ring with the safety center unit.



Bottom Ring — Should be auxiliary oil control ring properly ported for adequate drainage with adequate unit pressure for maximum oil control. Example: WAUSAU CHANNEL OIL.

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